BARR & STROUD LIMITED

ELECTRONIC FILTER SYSTEM EF3

Incorporating Filter Units

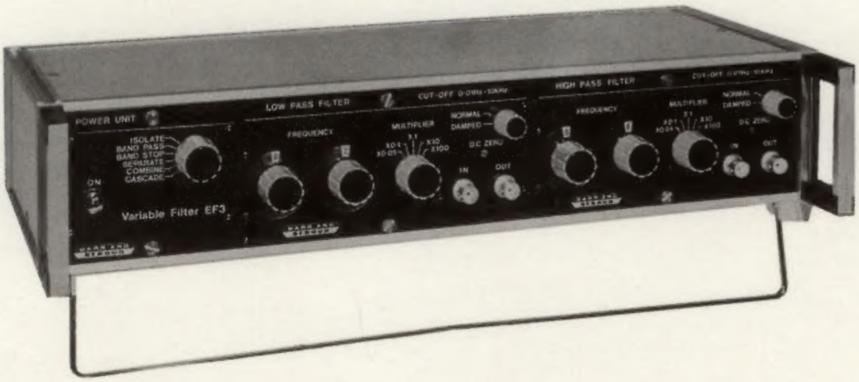
EF3-01 (high-pass) and EF3-02 (low-pass)
EF3-03 (high-pass) and EF3-04 (low-pass)

TECHNICAL HANDBOOK

BARR AND STROUD

No 1756a

ELECTRONIC FILTER SYSTEM EF3



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EF3-03 (high-pass) and EF3-04 (low-pass)

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SECTION 1 - SYSTEM DATA

1. Introduction

Electronic Filter System EF3 creates the opportunity to build up filter instrumentation by the most economical and convenient method - interchangeable filter units which plug into a basic power unit.

The low-profile cabinet, contains the plug-in power unit and up to two plug-in filter units. These can be switched to operate individually, or in cascade, or in other combinations to provide filtering modes such as band-pass, band-stop, band-separate and band-combine.

Technical details of plug-in filter units currently available are given in subsequent sections of this handbook.

2. Description

The cabinet has two bays which accommodate the selected plug-in filter units. The units locate easily on fixed rails with connections completed by plug and socket breaks. Each unit is secured in the cabinet by two fasteners.

The cabinet is designed for bench mounting, and has an integral folding stand to facilitate operation of controls. The cabinet can be adapted for 19-inch rack mounting, if required, using conversion kit No. EF3954 (see Figure 1).

Weight of cabinet with power unit and two filter units is 4.5kg.

A. Power Unit

The power unit can be mains or battery operated, and provides stabilised 15V positive and negative supplies to the filter units. Mains and battery connectors are on the rear. The mains ON/OFF switch on the front of the unit does not control the battery supplies.

The supply requirements are:

Mains :	205 to 245V (110V tap), 25W, 50/60 Hz, maximum mains variation $\pm$ 7% on voltage.
Battery :	+24V and −24V at 100mA per filter unit, maximum battery variation $\pm$ 15% on voltage.

The 15V positive and negative lines are separately fused (250mA). The fuses are on the printed circuit board within the power unit. A spare fuse is also present on the board. The mains transformer is protected by a 250mA fuse accessible from the rear of the instrument.

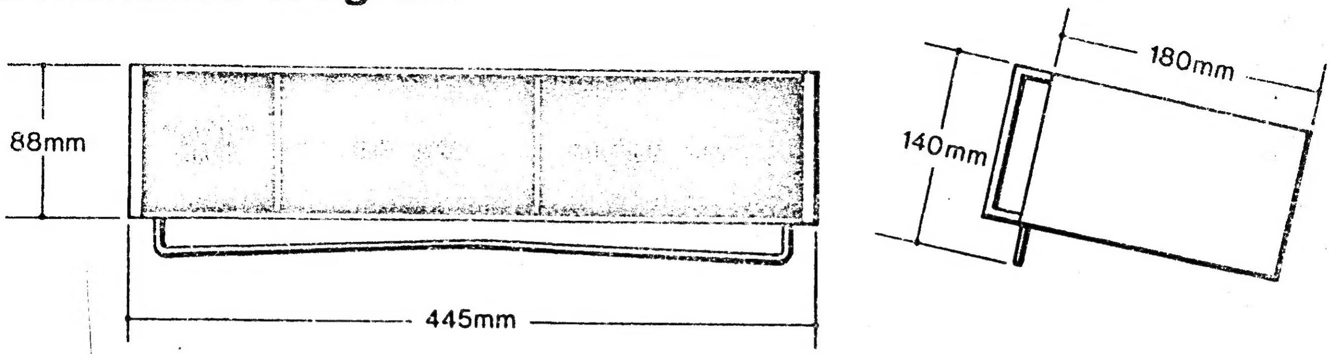
The battery sockets are permanently connected across the bridge rectifier and are therefore 'live' while the unit is being operated by mains supply. Two diodes are connected in series with the battery sockets to protect against inadvertent external 'shorting' of the sockets when using a mains supply. The diodes also protect against accidental reversal of battery polarities.

The power unit circuit diagram is shown on Figure 5 (EF3-16 power units) or Figure 5A (EF3-17 power units).

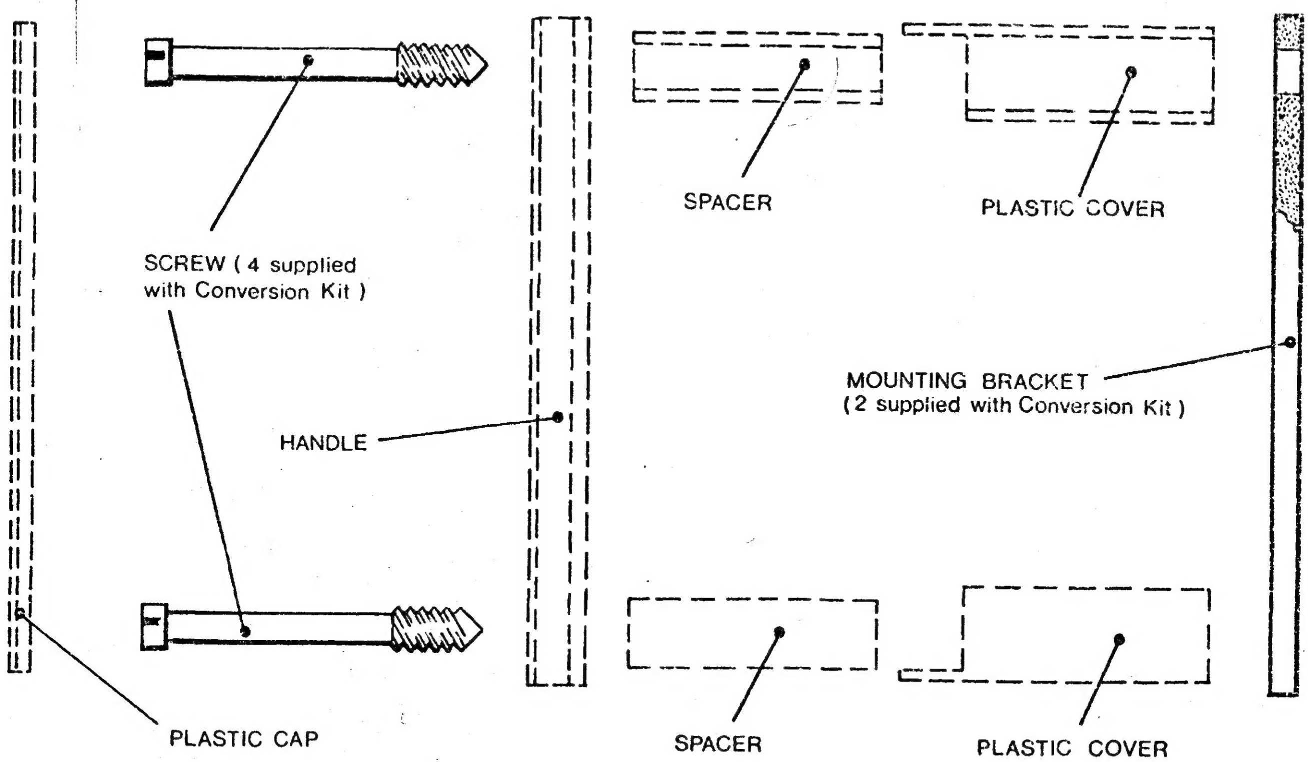
B. Environmental conditions

Operating temperature range	$0^{o}C$ to + $45^{o}C$
Storage temperature range	$-20^{o}C$ to + $80^{o}C$

Dimensions Diagram



Conversion Kit No. EF3954 (for 19-inch rack mounting)



Note:

Items with solid lines are the components of Conversion Kit. No. EF3954. Items with broken lines are components of the handle.

Instructions:

(1) Remove plastic cap from handle.
(2) Unscrew and remove the two handle screws.
(3) Position mounting bracket between cabinet and handle spacer, aligning bracket holes with those in cabinet.
(4) Secure handle using two conversion kit screws.
(5) Fit plastic cap.

Dimensions Diagram and Conversion Kit
Figure 1

SECTION 2 - PLUG-IN FILTER UNITS

1. High-Pass Filter Unit EF3-01

EF3-01 can be used in the basic cabinet with the power unit, either as a single filter unit or cascaded with a second EF3-01 unit for increased attenuation rate. More generally it is used with a low-pass filter unit from System EF3 to provide a full range of modes: band-pass, band-stop, band-separate, and band-combine.

The EF3-01 has a response, expressed in terms of maximum 3dB bandwidth from 0.01Hz to 500kHz. Cut-off frequency is variable from 0.01Hz to 10kHz and is selected by digital controls consisting of 2 decade switches and a 5 range multiplier. Digital selection has the advantage of accurate repeatability of setting.

The filter response is 8-pole Butterworth for flattest passband response with a nominal final attenuation rate of 48dB/octave in the cut-off region. A damped characteristic can be selected for minimum distortion of complex waveforms.

Input and output connections are via BNC sockets on the front panel with parallel sockets at the rear. The unit is protected against accidental damage by output short circuit.

A. Specification

Maximum 3dB bandwidth	0.01Hz to 500kHz	
Cut-off frequency F_c	variable from 0.01Hz to 10kHz	
Calibration accuracy	$\pm 3\%$ on frequency setting	
Attenuation rate	48dB/octave	see Figure 2
Passband insertion loss	0 ± 0.5dB	see Figure 2
Insertion loss at F_c (normal mode)	3 ± 0.5dB	see Figure 2
Insertion loss at F_c (damped mode)	14 ± 2dB	see Figure 2
Final attenuation	>85 dB	
Passband limit	6dB/octave falling off from 500kHz to 1 MHz thereafter 12dB/octave	
Phase response	see Figure 2	
Maximum input signal	7V peak (5V rms)	
Permissible d.c. component	150Vmaximum at input	
Maximum output current	normally 20mA (guaranteed 10mA)	
Harmonic distortion	$<0.2\%$ below 500kHz	
Input impedance	4MΩ in parallel with 60pF	
Output impedance	50Ω	
Offset d.c. drift/time	typically $\pm$ 1m V/day after 2 hour warm-up period	
Offset d.c. drift/temp.	typically $<100\mu V/^{o}C$ after 2 hour warm-up period	
Change in offset d.c. volts	25mV maximum over the whole F_c range	

Warm-up period	5 minutes for maximum a.c. signal handling
Noise level	300µV rms over 500 kHz bandwidth, with input short circuited (battery or mains operated)

All values stated are nominal unless tolerances are specified.

B. Circuit description

EF3-01 filter unit has been synthesised using R-C ladder networks in conjunction with operational amplifiers. The design method used permits the realisation of an 8-pole characteristic by cascading four 2-pole sections.

Figure 6 shows the circuit detail of the unity gain amplifiers on the plug-in amplifier board and the pin connections from the edge connector (SK2) to the R-C switch sections. Details of the R-C switch sections are shown on Figure 8.

R46 is adjusted to set the gain of X8.

R10 equalises the insertion loss on the x 100 range of the high-pass unit. On all other high-pass ranges the insertion loss is constant and R10 is not in circuit.

R20 and R28 are adjusted to provide the correct feedback to ensure that the frequency response is within the prescribed limits.

X8, the output amplifier, has greater than unity gain (18dB approx.) to compensate for losses in the remainder of the network.

2. Low-pass Filter Unit EF3-02

EF3-02 can be used in the basic cabinet with the power unit, either as a single filter unit or cascaded with a second EF3-02 unit for increased attenuation rate. More generally it is used with a high-pass filter unit from System EF3 to provide a full range of modes: band-pass, band-stop, band-separate, and band-combine.

The EF3-02 has a maximally flat response from d.c. to 10 kHz. Cut-off frequency is variable from 0.01Hz to 10 kHz and is selected by digital controls consisting of 2 decade switches and a 5 range multiplier. Digital selection has the advantage of accurate repeatability of setting.

The filter response is 8-pole Butterworth for flattest passband response with nominal final attenuation rate of 48dB/octave in the cut-off region. A damped characteristic can be selected to provide linear phase response for minimum distortion of complex waveforms.

Input and output connections are via BNC sockets on the front panel with parallel sockets at the rear. The unit is protected against accidental damage by output short-circuit.

A. Specification

Maximum bandwidth	d.c. to 10kHz (3dB down)	
Cut-off frequency F_c	variable from 0.01Hz to 10 kHz	
Calibration accuracy	± 3% on frequency setting	
Attenuation rate	48dB/Octave	see Figure 3
Passband insertion loss	0 ± 0.5dB	see Figure 3

Insertion loss at F_c (normal mode)	3 ± 0.5dB	see Figure 3
Insertion loss at F_c (damped mode)	14 ± 2dB	
Final attenuation	>75 dB to 2 MHz (min)	
Phase & delay response	see Figure 3	
Square-wave response	see Figure 3	
Maximum input signal	7V peak (5V rms) or 7 V d.c. (combined a.c. and d.c. components of input must not exceed 7V peak)	
Maximum output current	normally 20mA (guaranteed 10mA)	
Harmonic distortion	< 0.2 % below 10kHz	
Input impedance	4MΩ in parallel with 60pF	
Output impedance	50Ω	
Offset d.c. drift/time	typically $\pm$ 1mV/day after 2 hour warm-up period	
Offset d.c. drift/temp.	typically < 100 μV /^{o}C after 2 hour warm-up period	
Change in offset d.c. volts	25 mV maximum over the whole F_c range	
Noise level	200μV r m s over 10kHz bandwidth, with input short-circuited (battery or mains operated)	

All values stated are nominal unless tolerances are specified.

B. Circuit description

EF3-02 filter unit has been synthesised using R-C ladder networks in conjunction with operational amplifiers. The design method used permits the realisation of an 8-pole characteristic by cascading four 2-pole sections.

Figure 6 shows the circuit detail of the unity gain amplifiers on the plug-in amplifier board and the pin connections from the edge connector (SK 2) to the R-C switch sections. Details of the R-C switch sections are shown on Figure 8.

R46 is adjusted to set the gain of X8.

R20 and R28 are adjusted to provide the correct feedback to ensure that the frequency response is within the prescribed limits.

X8, the output amplifier, has greater than unity gain (18dB approx.) to compensate for losses in the remainder of the network.

3. High-pass Filter Unit EF3-03

EF3-03 can be used in the basic cabinet with the power unit, either as a single filter unit or cascaded with a second EF3-03 unit for increased attenuation rate. More generally it is used with a low-pass filter unit from System EF3 to provide a full range of modes: band-pass, band-stop, band-separate, and band-combine.

The EF3-03 has a response, expressed in terms of maximum 3 dB bandwidth from 0.1Hz to 700kHz. Cut-off frequency is variable from 0.1 Hz to 100kHz and is selected by digital controls consisting of 2 decade switches and a 5 range multiplier. Digital selection has the advantage of accurate repeatability of setting.

The filter response is 8-pole Butterworth for flattest passband response with a nominal final attenuation rate of 48dB/octave in the cut-off region. A damped characteristic can be selected for minimum distortion of complex waveforms.

Input and output connections are via BNC sockets on the front panel with parallel sockets at the rear. The unit is protected against accidental damage by output short-circuit.

A. Specification

Maximum 3dB bandwidth	0.1 Hz to 700 kHz	
Cut-off frequency F_c	variable from 0.1Hz to 100kHz	
Calibration accuracy	$\pm$ 3% on frequency setting	
Attenuation rate	48dB/octave	see Figure 2
Passband insertion loss	0 $\pm$ 0.5dB	see Figure 2
Insertion loss at F_c (normal mode)	3 $\pm$ 0.5dB	see Figure 2
Insertion loss at F_c (damped mode)	16 $\pm$ 2 dB	see Figure 2
Final attenuation	>85 dB	
Passband limit	6dB/octave falling off from 700kHz to 1.5MHz thereafter 12dB/octave	
Phase response	see Figure 2	
Maximum input signal	7V peak (5V rms) up to 300kHz reducing to 2.5V peak at 700kHz for undistorted operation.	
Permissible d.c. component	150V maximum at input	
Maximum output current	normally 20mA (guaranteed 10mA)	
Harmonic distortion	< 0.2% below 700kHz	
Input impedance	4MΩ in parallel with 60 pF	
Output impedance	50Ω	

Offset d.c. drift/time	typically $\pm$ 1m V/day after 2 hour warm-up period
Offset d.c. drift/temp.	typically $<100\mu V/^{\circ}C$ after 2 hour warm-up period
Change in offset d.c. volts	3mV over the whole F_c range
Noise level	350μV rms over 700kHz bandwidth, with input short-circuited (battery or mains operated).

All values stated are nominal unless tolerances are specified.

B. Circuit description

EF3-03 filter unit has been synthesised using R-C ladder networks in conjunction with operational amplifiers. The design method used permits the realisation of an 8-pole characteristic by cascading four 2-pole sections.

Figure 9 shows the circuit detail of the unity gain amplifiers on the plug-in amplifier board and the pin connections from the edge connector (SK2) to the R-C switch sections. Details of the R-C switch sections are shown on Figure 8.

R10 is adjusted to equalise the insertion loss on the x 1K range of the high-pass unit. On all other high-pass ranges the insertion loss is constant and R10 is not in circuit.

R20 and R28 are adjusted to provide the correct feedback to ensure that the frequency response is within the prescribed limits.

X8, the output amplifier, has greater than unity gain (18dB approx.) to compensate for losses in the remainder of the network.

R46 is adjusted to set the gain of X8.

4. Low-pass Filter Unit EF3-04

EF3-04 can be used in the basic cabinet with the power unit, either as a single filter unit or cascaded with a second EF3-04 unit for increased attenuation rate. More generally it is used with a high-pass filter unit from System EF3 to provide a full range of modes: band-pass, band-stop, band-separate, and band-combine.

The EF3-04 has a maximally flat response from d.c. to 100kHz. Cut-off frequency is variable from 0.1Hz to 100kHz and is selected by digital controls consisting of 2 decade switches and a 5 range multiplier. Digital selection has the advantage of accurate repeatability of setting.

The filter response is 8-pole Butterworth for flattest passband response with nominal final attenuation rate of 48dB/octave in the cut-off region. A damped characteristic can be selected to provide linear phase response for minimum distortion of complex waveforms.

Input and output connections are via BNC sockets on the front panel with parallel sockets at the rear. The unit is protected against accidental damage by output short-circuit.

A. Specification

Maximum bandwidth	d.c. to 100kHz (3dB down)
Cut-off frequency F_c	variable from 0.1Hz to 100kHz
Calibration accuracy	$\pm$ 3% on frequency setting
Attenuation rate	48dB/octave (see Figure 3)
Passband insertion loss	0 $\pm$ 0.5dB (see Figure 3)
Insertion loss at F_c (normal mode)	3 $\pm$ 0.5dB (see Figure 3)
Insertion loss at F_c (damped mode)	16 $\pm$ 2 dB (see Figure 3)
Final attenuation	>75 dB up to 5 MHz >60 dB up to 10 MHz
Phase & delay response	see Figure 3
Square-wave response	see Figure 3
Maximum input signal	7V peak (5V rms) or 7V d.c. (combined a.c. and d.c. components of input must not exceed 7V peak)for undistorted operation
Maximum output current	normally 20mA (guaranteed 10mA)
Harmonic distortion	< 0.2% below 100kHz
Input impedance	4MΩ in parallel with 60pF
Output impedance	50Ω
Offset d.c. drift/time	typically $\pm$ 1mV/day after 2 hour warm-up period
Offset d.c. drift/temp.	typically <100μV/°C after 2 hour warm-up period
Change in offset d.c. volts	3mV over the whole F_c range
Noise level	250μV rms over 100kHz bandwidth, with input short-circuited (battery or mains operated)

All values stated are nominal unless tolerances are specified.

B. Circuit description

EF3-04 filter unit has been synthesised using R-C ladder networks in conjunction with operational amplifiers. The design method used permits the realisation of an 8-pole characteristic by cascading four 2-pole sections.

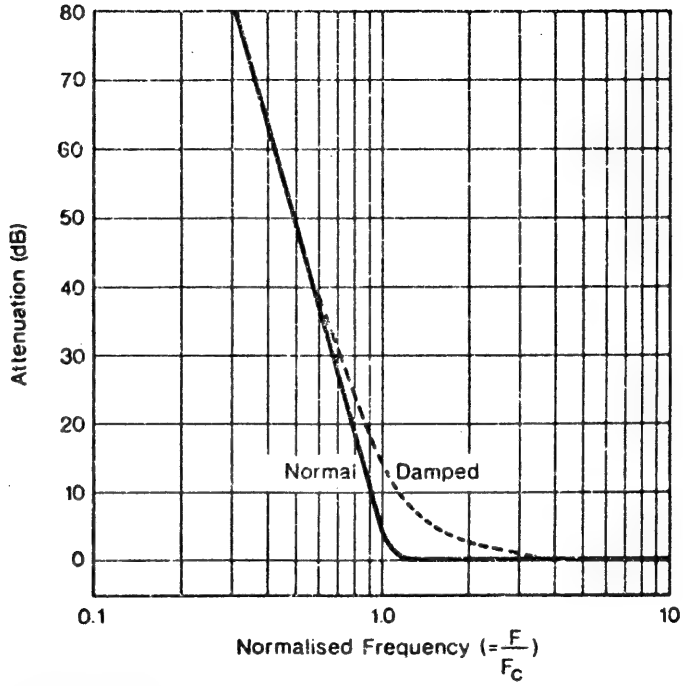
Figure 9 shows the circuit detail of the unity gain amplifiers on the plug-in amplifier board and the pin connections from the edge connector (SK2) to the R-C switch sections. Details of the R-C switch sections are shown on Figure 8.

R20 and R28 are adjusted to provide the correct feedback to ensure that the frequency response is within the prescribed limits.

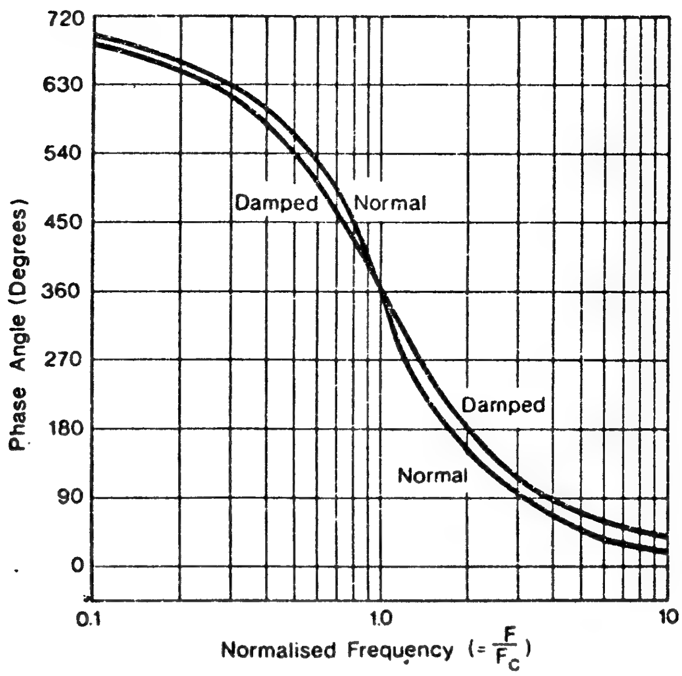
X8, the output amplifier, has greater than unity gain (18dB approx.) to compensate for losses in the remainder of the network.

R46 is adjusted to set the gain of X8.

Attenuation

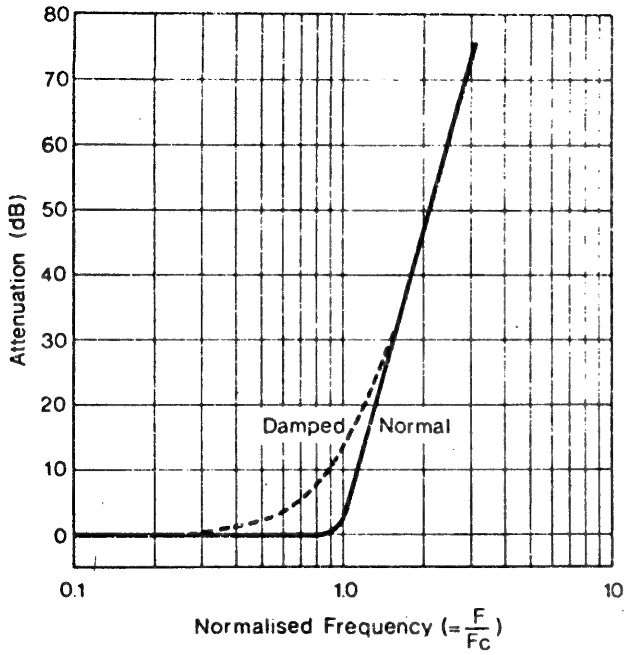


Phase

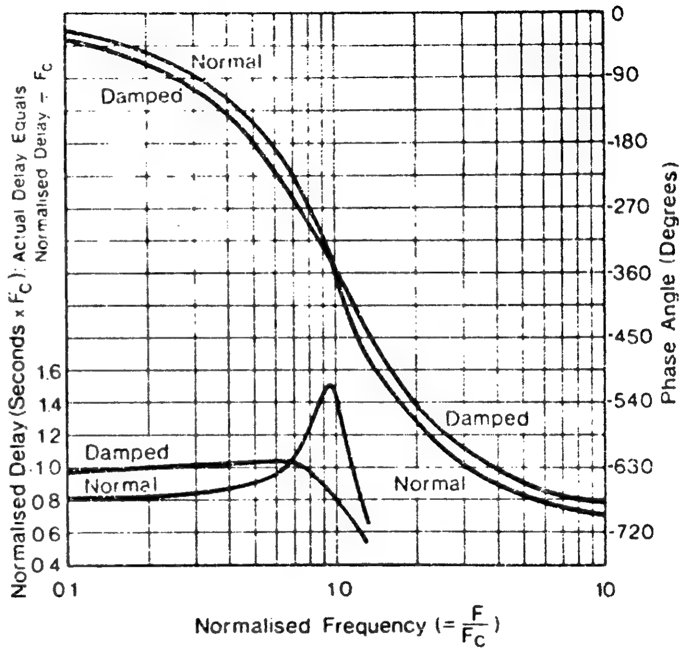


Response: High-Pass Filter Units
EF3-01 & EF3-03 **Figure 2**

Attenuation



Phase & Delay



Typical Square-wave Response

Filter unit switch setting, F_c = 10kHz, 500Hz square-wave input.

Figure 3 - Normal Mode

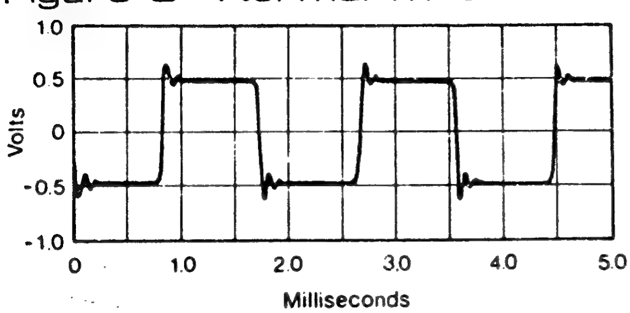
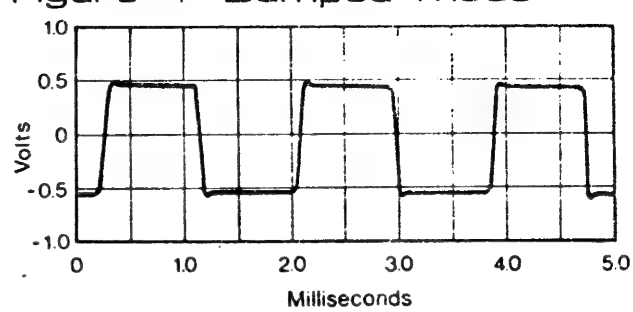


Figure 4 - Damped Mode



Response: Low-Pass Filter Units EF3-02 & EF3-04

Figure 3

SECTION 3 - LINKED OPERATION

1. Filter Units EF3-01(high-pass) & EF3-02(low-pass); EF3-03(high-pass) & EF3-04(low-pass)

These filter units provide the following range of operational modes:

(a) Isolate - two filter units available for independent use.
(b) Band-Pass
(c) Band-Stop
(d) Band-Separate
(e) Band-Combine

(b)–(e): one high-pass unit & one low-pass unit interconnected

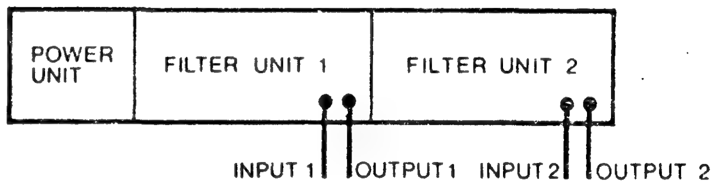
(f) Cascade - two filter units of the same type, connected in series.

Appropriate interconnections are made by the mode selection switch on the power unit. Signal connections are shown in the diagrams.

NOTE: All values stated are nominal unless tolerances are specified.

A. Isolate

This mode permits independent use of two filter units.



B. Band-Pass

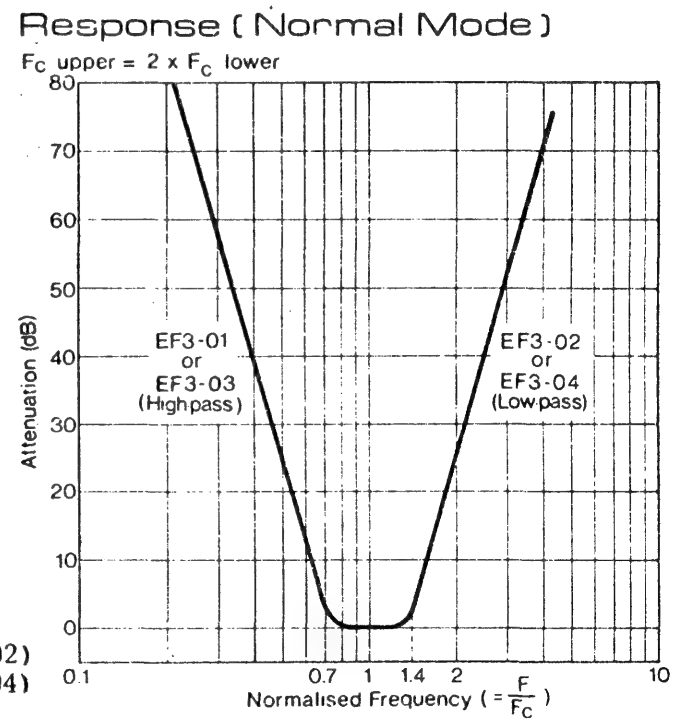
Attenuation slopes outside the passband are 48dB/octave.

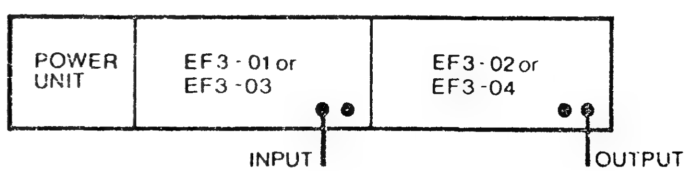
Passband insertion loss is dependent on the ratio between the upper and lower cut-off frequencies as follows:

(a) When $\frac{\text{Fc upper}}{\text{Fc lower}} \geq 1.6$,
insertion loss = 0 ± 1dB.

(b) When $\frac{\text{Fc upper}}{\text{Fc lower}}$ approaches 1.0,
insertion loss increases to approximately 6dB(normal mode)
28dB (damped mode EF3-01 & EF3-02)
32dB (damped mode EF3-03 & EF3-04)

Input impedance is 4MΩ in parallel with 60 pF.





C. Band-Stop

Attenuation slopes are 48dB/octave.

Midband frequency attenuation is dependent on the ratio between the upper and lower cut-off frequencies as follows:

(a) When $\frac{\text{Fc upper}}{\text{Fc lower}} \geq 4$, attenuation ≥ 42dB.

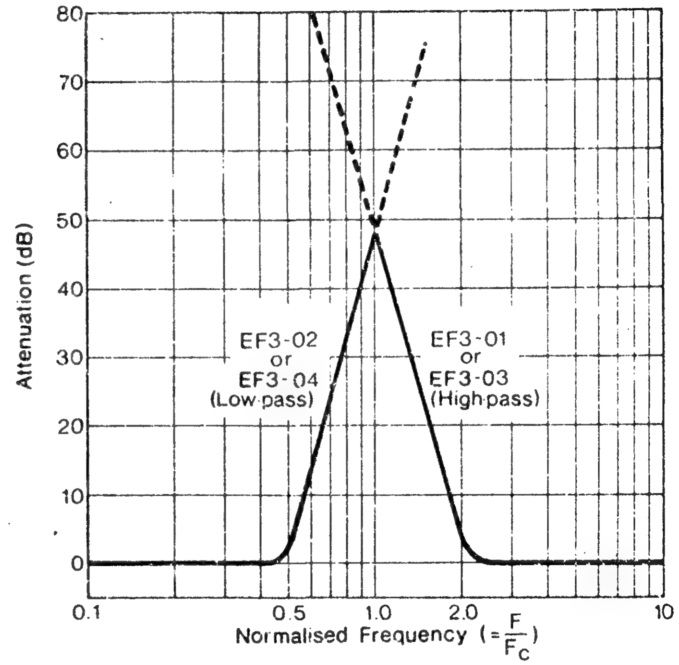
(b) When $\frac{\text{Fc upper}}{\text{Fc lower}}$ approaches 1.0, attenuation is decreased to approximately 0dB (normal mode) 10dB (damped mode).

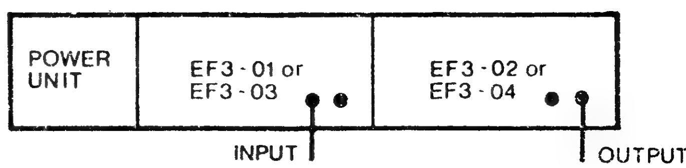
Input impedance is 2MΩ in parallel with 120 pF.

The output amplifier of the right-hand filter unit compensates for the summing losses in R35 and R42 (see circuit diagrams Figs.6 & 9).

Response (Normal Mode)

F_c upper = 4 x F_c lower

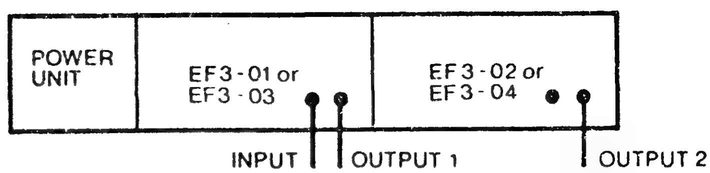




D. Band-Separate

Attenuation slopes are 48dB/octave.

Input impedance is 2MΩ in parallel with 120 pF.

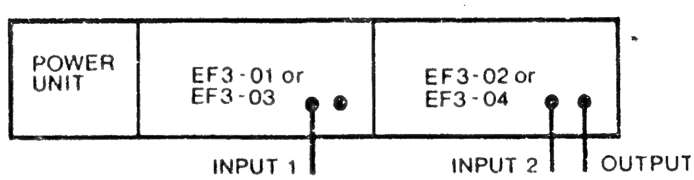


E. Band-Combine

Attenuation slopes are 48dB/octave.

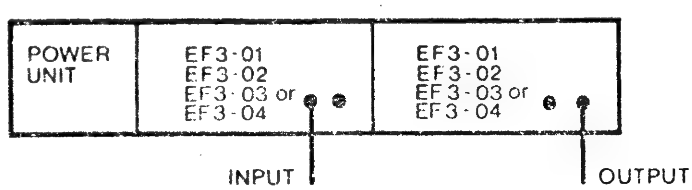
Input impedance for each unit is nominally 4MΩ in parallel with 60 pF.

The output amplifier of the right-hand filter unit compensates for the summing losses in R35 and R42 (see circuit diagrams Figs.6 & 9).



F. Cascade

Insertion loss at the selected cut-off frequency is approximately 6dB (normal mode) 28dB (damped mode EF3-01 & EF3-02) 32dB (damped mode EF3-03 & EF3-04)



SECTION 4 - OPERATION

1. Operating Controls

A. Frequency selection switches

Two frequency selection switches and a multiplier switch on each filter unit determine the cut-off frequency (in the normal mode the 3 dB attenuation frequency is commonly referred to as the cut-off frequency). The left-hand frequency selection switch is calibrated in 'tens' and the other is calibrated in 'units'. Cut-off frequency is derived from the sum of the readings on the 'tens' and 'units' switch multiplied by the multiplier switch setting.

B. Multiplier switch

This switch has five positional settings providing multiplying factors of 0.01, 0.1, 1.0, 10 and 100, (EF3-01 & EF3-02), and 0.1, 1.0, 10, 100, 1K, (EF3-03 & EF3-04).

C. Response switch

The response switch controls the form of response provided by the unit. It has two settings as follows:

(i) Normal - which provides a response similar to that of an 8-pole Butterworth function and therefore, has the flattest monotonic passband response possible; it has 3 dB attenuation at the cut-off frequency, thereafter increasing at the rate of 48dB/octave.

(ii) Damped - which provides an improved filter phase response, effectively reducing ringing and overshoot on pulse and step-type waveforms. This is particularly useful in the low-pass unit. Attenuation at the selected cut-off frequency increases to approximately 14dB (EF3-01 & EF3-02) 16dB (EF3-03 & EF3-04); the 3dB frequency is at approximately 0.5 x the selected frequency in the low-pass unit and 2 x the selected frequency in the high-pass unit.

D. d.c. zero control

This enables the output of the unit to be set to zero volts d.c.

E. Mode switch

This is situated on the power unit and enables the two filter units to be used as individual or combined units depending on the required mode of operation. The mode switch has six positions which are:

(i) Isolate - The two filter units are isolated from one another both at the input and output, but share the power supply.

(ii) Band-Pass - The output of the left-hand unit is connected to the input of the right-hand unit and provides band-pass facilities when one high-pass and one low-pass unit is used (it is usual to insert the high-pass unit in the left-hand position to eliminate any d.c. component present in the input). The high-pass unit determines the lower band-edge frequency and the low-pass unit the upper band-edge frequency. Input connection is made to the left-hand unit and bandpass output taken from the right-hand unit.
Signals present in the stop band of the right-hand unit are available at the output of the left-hand unit.

NOTE In band-pass operation if both units are set to the same cut-off frequency a 6 ± 1dB loss will occur at the mid-band with the response switch in the 'normal position'.

(iii) Band-Stop - One high-pass and one low-pass unit are required for this mode. The inputs and outputs of the two units are connected in parallel. Input may be connected to either input socket but output containing both passbands is available from the right-hand unit only.

(iv) Separate - The inputs of the two units are connected in parallel but the outputs are independent of one another. Input signal may be connected to either input socket.

(v) Combine - The inputs of the two units are independent of each other and will therefore accept two separate signals. The combined output is available at the right-hand unit only.

(vi) Cascade - The output of the left-hand unit is connected to the input of the right-hand unit to enable two low-pass or two high-pass units to be used to obtain an increased cut-off rate. Alternatively, two different high-pass or low-pass bandwidths can be obtained by setting the left-hand unit to the wider band.

2. Setting Up

A. Power supply connection

System EF3 can be powered by mains or battery supply. Before connecting to a mains supply, it is essential that the correct voltage is selected at the mains transformer (the instrument is despatched with the transformer adjusted for 240V a.c., 50/60 Hz mains supply).

Mains supply connection is made to a socket on the rear of the power unit by a 3-core cable provided with the instrument. Wire identification is as follows: brown - line; blue - neutral; green/yellow - ground. Battery supply connection is made to three 4mm sockets in the rear of the power unit. These sockets are colour coded as follows: red - +24V; yellow - -24V; black - common or ground.

B. Set d.c. zero at output

Proceed as follows:

(a) High-pass unit

(i) With input open-circuited, connect a suitable d.c. voltmeter to the output.
(ii) Adjust the preset control R38 (d.c. zero) for zero on the meter.

NOTE Because the input is capacitively coupled, short-circuiting of the input is not required.

(b) Low-pass unit

(i) With input short-circuited, connect d.c. voltmeter to output.
(ii) Adjust the preset control R38 (d.c. zero) for zero on the meter.

(iii) Remove short-circuit from input.

NOTE Small changes in the d.c. offset at the filter output may occur when the digital switch settings are changed. Maximum variation over the whole range of settings is 25 mV (EF3-01 & EF3-02) and 3mV (EF3-03 & EF3-04).

C. Signal connection

Connect signal to the appropriate sockets as determined by the required filtering mode. The diagrams in Section 3 indicate the various connection arrangements.

3. Operating Procedure

The operating procedure consists of correctly setting the two frequency selection switches and the multiplier switch.

e.g.	'Tens' Switch Setting	2 = 20 (i.e. 2 x 10)
	'Units' Switch Setting	5
	Sum of Switch Settings	25
	Multiplier Switch Setting	x 10
	Cut-off Frequency	25 x 10 = 250Hz

NOTE When filters are used independently of one another in the same frame the level of isolation between the units is determined in some measure by the source impedances. If the source impedance connected to the input is less than 10KΩ then the isolation exceeds 60dB. For 100KΩ source this reduces to 50dB approximately and on open circuit to approximately 20dB down, at the output of the unenergised unit. The level of isolation exceeds the stop band attenuation for source impedances less than 1.0KΩ.

SECTION 5 - FAULT FINDING

The following a.c. and d.c. voltages are given as an aid to fault location. These should be used for guidance only.

All voltages are measured with respect to Pin 1.

Measure the a.c. voltages as follows:

(1) Apply a 2V a.c. signal to the input.
(2) Set response switch to 'normal'.
(3) Set the filter cut-off so that the test signal frequency is well within the passband, e.g. approximately 1/5 the cut-off frequency for low-pass or 5 times the cut-off frequency for high-pass.
(4) Set mode switch to 'isolate'.

NOTES (i) Input and subsequent measurements may be either peak or rms as appropriate.
(ii) The x 100 range in EF3-01 and the x 1K range in EF3-03 should not be used for checking as the a.c. voltages on these ranges differ from those listed in the tables.

Table 1 - Edge Connector SK2; EF3-01/EF3-02/EF3-03/EF3-04

PIN No.	EF3-01/-02/-03/-04 a.c. VOLTS	EF3-01/-02/-03/-04 d.c. VOLTS
1	0V	0V
2	0V	+15V ± 0.5V (supply)
3	2.0V	0V ± 25mV
4	1.0V ± 50mV	" "
5	0V	-15V ± 0.5V (supply)
6	0V	0V
7	1.0V ± 50mV	0V ± 25mV
8	" " (-6dB)	" "
9	" "	" "
10	" "	" "
11	" " (-6dB)	" "
12	" "	" "
13	" " (-6dB)	" "
14	0.34V ± 50mV (-16.48dB)	" "
15	0V	-2.5V ± 0.5V
16	1.0V ± 50mV	0V ± 25mV
17	" " (-6dB)	" "
18	" "	" "
19	" " (-6dB)	" "
20	0.94V ± 50mV (-7.43dB for S/N <296)	" "
21	" "	" "
22	1.0V ± 50mV	" "
23	" " (-6dB)	" "
24	" "	" "
25	" "	" "
26	0.19V ± 50mV	" "
27	1.0V ± 50mV	" "
28	0V	+ 3.5V ± 0.5V
29	2.0V ± 50mV (o/p)	0V
30	0V	0V ± 1V
31	0V	0V
32	0V	0V

SECTION 6 - APPLICATION

In many systems it is necessary to introduce filtering to attenuate unwanted signals. The choice of a suitable filter network can be exceedingly difficult especially when it comes to specifying the required filter parameters. This task can be made easier by making use of a variable filter during the various stages of design. When the precise requirement has thus been established, fixed frequency passive or active networks can be designed and constructed in a suitable form for inclusion in the final equipment assembly. Barr & Stroud Limited design and produce such custom-built filter networks.

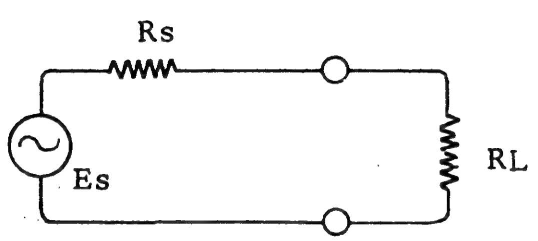
Consider the network shown on diagram A below, which represents a voltage source Es of resistance Rs and a resistive load termination RL. If Es is complex and some of its components are to be suppressed then a suitable filter must be introduced into the network as on diagram B. Such a filter would be designed to operate between source resistance Rs and load termination RL.

If a Variable Filter is inserted in such a network then the following points should be noted.

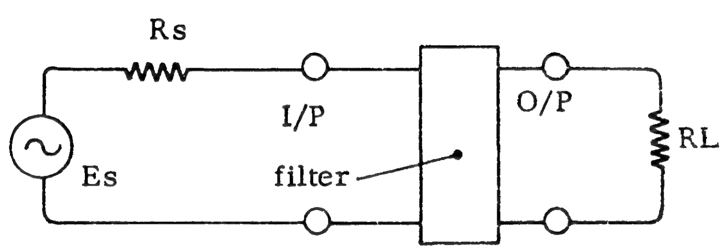
Because the input impedance of the variable filter is high a dummy load RL^1 should be introduced at its input. This serves two purposes; firstly, the signal source will then operate under its normal loaded condition and, secondly, the insertion loss response of the variable filter will then be the same as that which would be obtained if it were replaced by an equivalent fixed frequency passive network with terminations Rs and RL. In the case where the load termination RL approaches the output impedance of the variable filter then a fixed increase in the insertion loss will result.

When the variable filter is being used it may not however be necessary to introduce it between the source and load as shown on diagram C. To observe the effect of filtering on the signal waveform the variable filter may be connected across the load RL as shown on diagram D provided RL is small compared with the filter input impedance. The waveform of the filter output is then the same as that which would be obtained were the filter inserted between source and load as on diagram C.

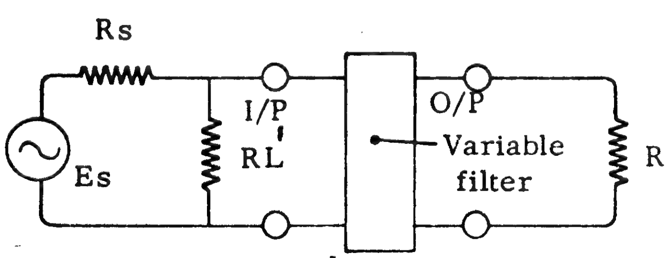
A. System to be filtered



B. System with desired filter

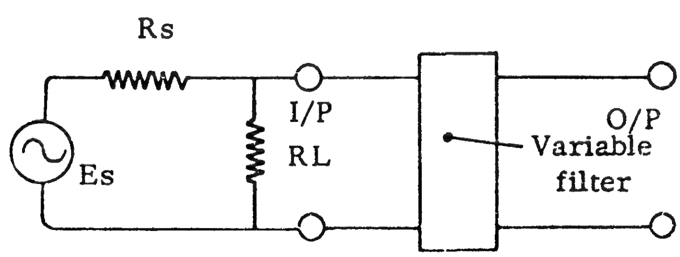


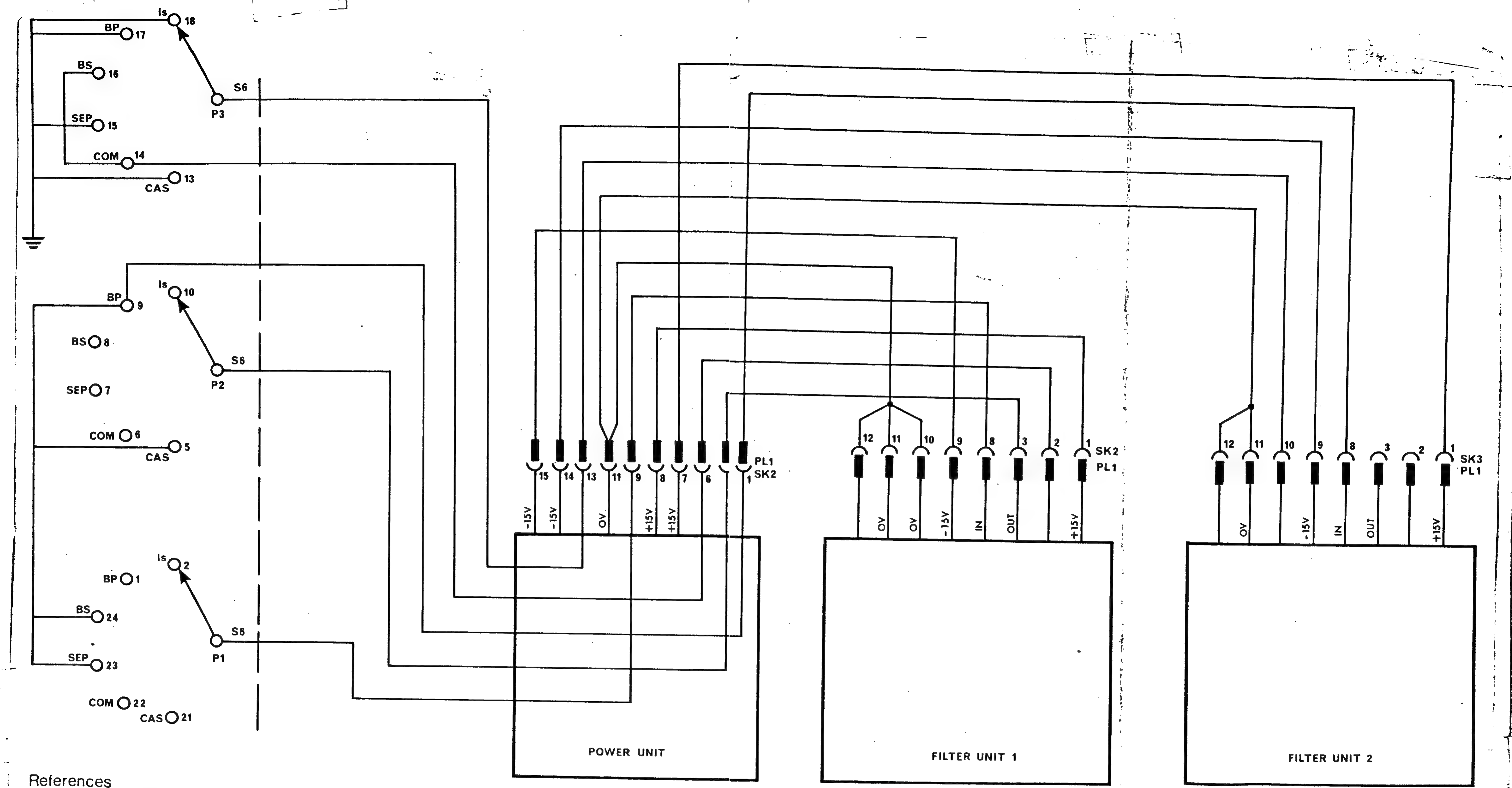
C. System with variable filter connected between source Rs & RL



Dummy load RL' = RL

D. System with variable filter input connected across load RL

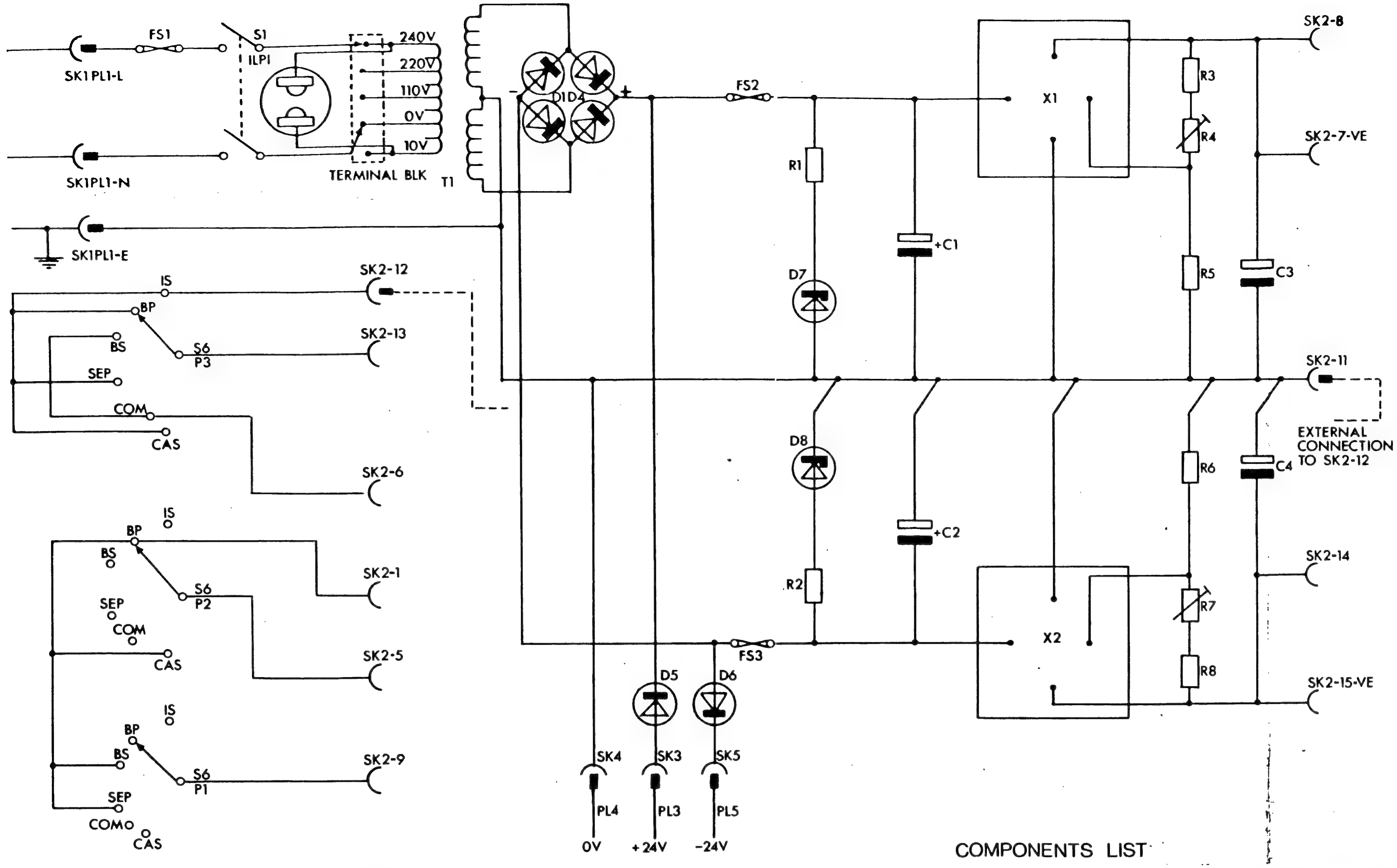


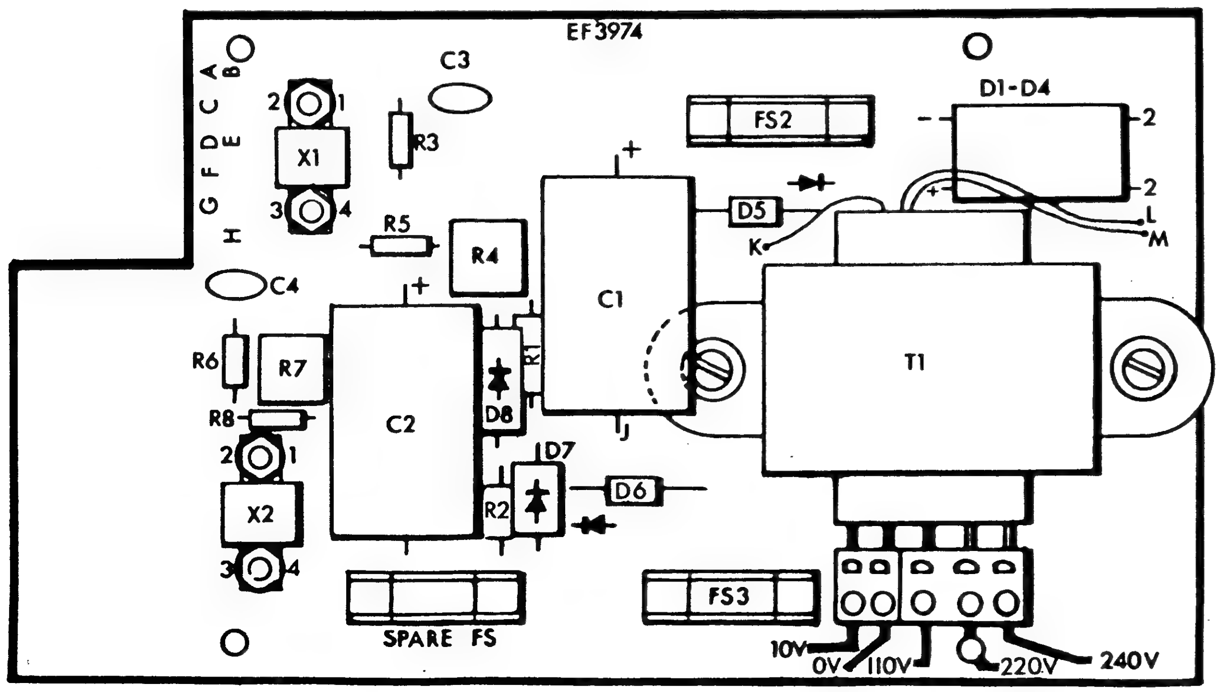


References

S6 — SWITCH B/EF3023
Is — ISOLATE
BP — BAND-PASS
BS — BAND-STOP
SEP — BAND-SEPARATING
COM — BAND-COMBINING
CAS — CASCADE

Mode Switching Diagram **Figure 4**





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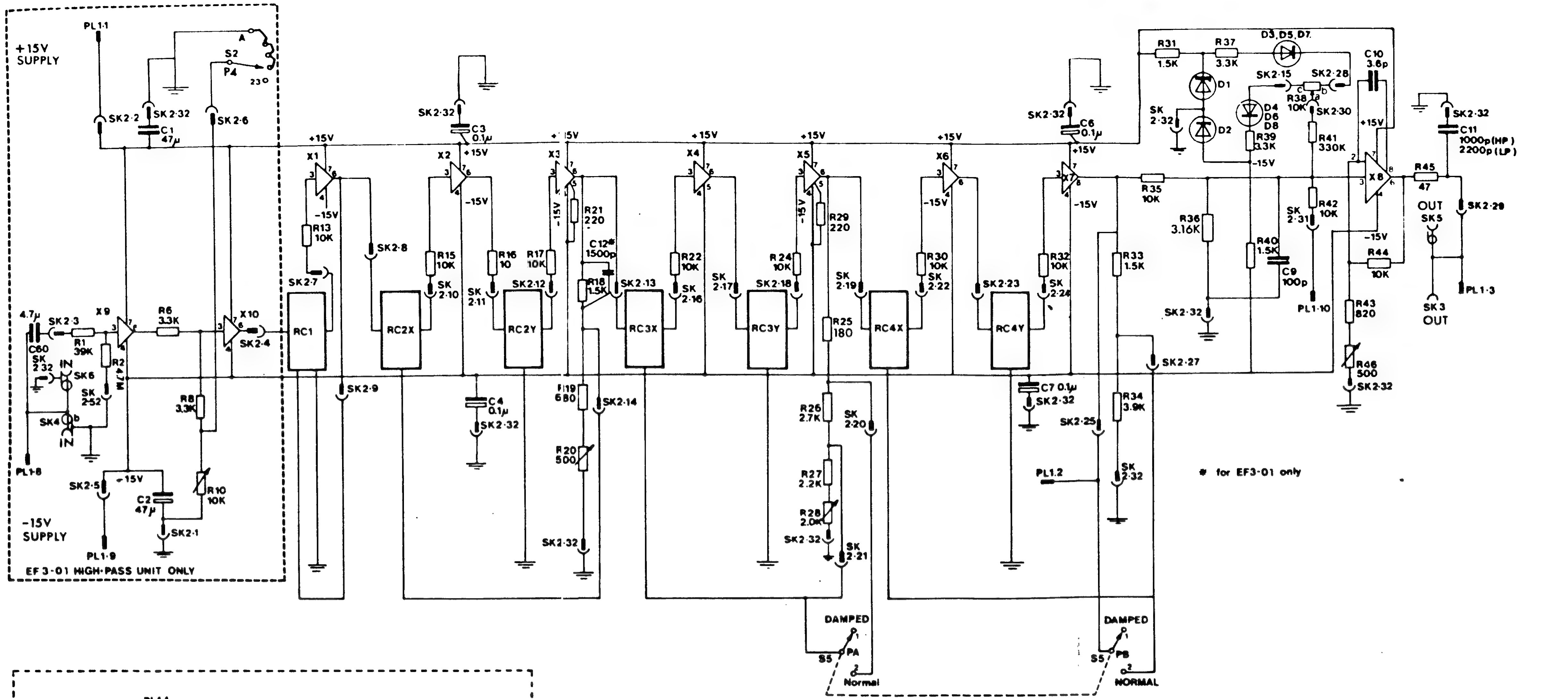
COMPONENTS LIST

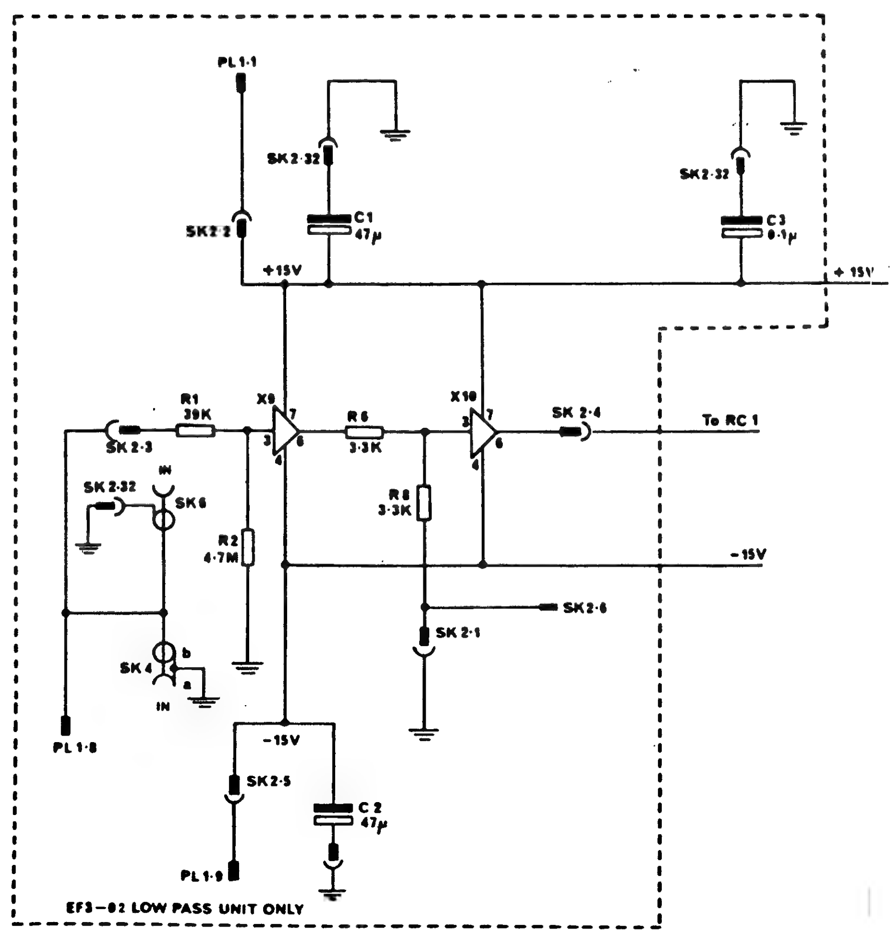
Circuit Ref.	Description	Ref. No.	Value	Tol.%	Rating
R1	Resistor	CR37	150Ω	± 5	0.5W
R2	–	–	–	–	–
R3	–	MR25	6K8	± 2	0.25W
R4	Potentiometer	72P	5K	± 20	0.5W
R5	Resistor	MR25	4K7	± 2	0.25W
R6	–	–	2K2	–	–
R7	Potentiometer	72P	5K	± 20	–
R8	Resistor	MR25	10K	± 2	–
C1	Capacitor	01717471	470µF	+50 −10	40V
C2	–	–	–	–	–
C3	–	TAG1.0/35	1µF	± 20	35V
C4	–	–	–	–	–
D1, D2, D3, D4	Bridge rectifier	10DB1A			
D5	Silicon diode	10D1			
D6	– –	–			
D7	– –	BZX70C30	30V	± 5	2W
D8	– –				
X1	Voltage regulator	78MGT2			
X2	– –	79MGT2			

Circuit Ref.	Description	Ref. No.	Value	Tol.%	Rating
FS1	Fuse, size 20 x 5mm dia.	L2081	250mA		
FS2	– – – –	–	–		
FS3	– – – –	–	–		
S1	Switch	WFD1B/EF 3023			
S6	–	–			
PL1	Plug	L1950			
PL3	–	L1716A/4/RD			
PL4	–	L1716A/4/BK			
PL5	–	L1716A/4/YL			
SK1	Socket	L1949			
SK2	–	DA 15S			
SK3	–	L1413/RD			
SK4	–	L1413/BK			
SK5	–	L1413/YL			
T1	Transformer PR10-0-110-220-240V;SEC24-0-24V	MS			17mA
ILP1	Lamp SGF9/A/RD/220-N				

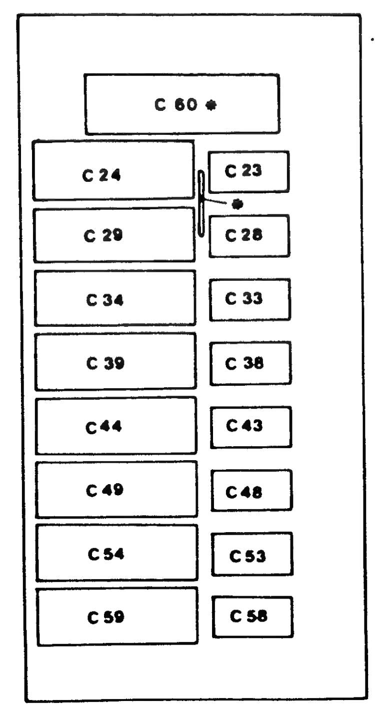
Circuit Diagram: Power Unit EF3-17

Figure 5

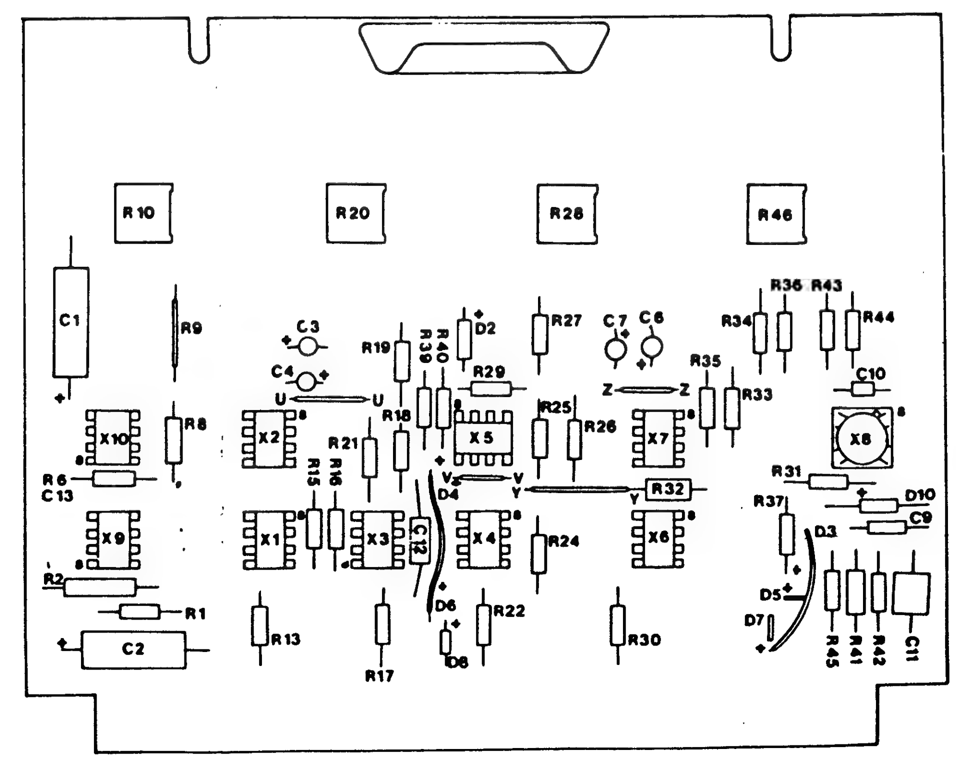




Capacitor Board



Printed Circuit Board



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Circuit Diagram: Filter Units EF3-01 & EF3-02

Figure 6

Filter Units EF 3-01 (High-Pass) & EF 3-02 (Low-Pass)

Circuit Ref.	Description	Ref. No.	Value Ω	Tol.%	Rating
R1	Resistor (Mullard)	CR 25	39K	±5	0.33W
R2	Resistor "	"	4.7M	±10	"
R6	Resistor (Mullard)	MR25	3.3K	±2	0.4W
R8	" "	"	"	"	"
R13	" "	CR25	10K	±5	0.33W
R15	" "	"	"	"	"
R16	" "	"	10Ω	"	"
R17	" "	"	10K	"	"
R18	" "	"	1.5K	"	"
R19	" "	"	680	"	"
R20	Resistor, Var. (Beckman)	72P	500	±20	0.5W
R21	Resistor (Mullard)	CR25	220	±5	0.33W
R22	" "	"	10K	"	"
R24	" "	"	"	"	"
R25	" "	"	180	"	"
R26	" "	"	2.7K	"	"
R27	" "	"	2.2K	"	"
R28	Resistor, Var. (Beckman)	72P	2.0K	±20	0.5W
R29	Resistor (Mullard)	CR25	220	±5	0.33W
R30	" "	"	10K	"	"
R31	" "	"	1.5K	"	"
R32	" "	"	10K	"	"
R33	" "	"	1.5K	"	"
R34	" "	"	3.9K	"	"
R35	" "	MR25	10K	±2	0.4W
R36	" "	"	3.16K	"	"
R37	" "	CR25	3.3K	±5	0.33W
R38	Resistor, Variable	A/EF3025	10K	±20	0.75W
R39	Resistor (Mullard)	CR25	3.3K	±5	0.33W
R40	" "	"	1.5K	±5	"
R41	" "	"	330K	"	"
R42	" "	MR25	10K	±2	0.4W
R43	" "	"	820	"	"
R44	" "	"	10K	"	"
R45	" "	CR25	47	±5	0.33W
R46	Resistor, (Var. (Beckman)	72P	500	±20	0.5W
R50	Resistor, Code Z	HOLCOH4	340 k	±1	0.25 W
R51	" "	"	169 k	±1	0.25 W
R52	" "	"	113 k	±1	0.25 W
R53	" "	"	84.5 k	±1	0.25 W
R54	" "	"	68.1 k	±1	0.25 W
R55	" "	"	56.2 k	±1	0.25 W
R56	" "	"	48.7 k	±1	0.25 W
R57	" "	"	42.2 k	±1	0.25 W
R58	" "	"	37.4 k	±1	0.25 W
R59	" "	"	340 k	±1	0.25 W
R60	" "	"	169 k	±1	0.25 W
R61	" "	"	113 k	±1	0.25 W
R62	" "	"	84.5 k	±1	0.25 W
R63	" "	"	68.1 k	±1	0.25 W
R64	" "	"	56.2 k	±1	0.25 W
R65	" "	"	48.7 k	±1	0.25 W
R66	" "	"	42.2 k	±1	0.25 W
R67	" "	"	37.4 k	±1	0.25 W
R68	" "	"	340 k	±1	0.25 W
R69	" "	"	169 k	±1	0.25 W
R70	" "	"	113 k	±1	0.25 W
R71	" "	"	84.5 k	±1	0.25 W
R72	" "	"	68.1 k	±1	0.25 W
R73	" "	"	56.2 k	±1	0.25 W
R74	" "	"	48.7 k	±1	0.25 W
R75	" "	"	42.2 k	±1	0.25 W
R76	" "	"	37.4 k	±1	0.25 W
R77	" "	"	133 k	±1	0.25 W
R78	" "	"	66.5 k	±1	0.25 W
R79	" "	"	44.2 k	±1	0.25 W
R80	" "	"	33.2 k	±1	0.25 W
R81	" "	"	26.7 k	±1	0.25 W
R82	" "	"	22.1 k	±1	0.25 W
R83	" "	"	18.7 k	±1	0.25 W
R84	" "	"	16.5 k	±1	0.25 W
R85	" "	"	14.7 k	±1	0.25 W
R86	" "	"	340 k	±1	0.25 W
R87	" "	"	169 k	±1	0.25 W
R88	" "	"	113 k	±1	0.25 W
R89	" "	"	84.5 k	±1	0.25 W
R90	" "	"	68.1 k	±1	0.25 W
R91	" "	"	56.2 k	±1	0.25 W
R92	" "	"	48.7 k	±1	0.25 W
R93	" "	"	42.2 k	±1	0.25 W
R94	" "	"	37.4 k	±1	0.25 W
R95	" "	"	340 k	±1	0.25 W
R96	" "	"	169 k	±1	0.25 W
R97	" "	"	113 k	±1	0.25 W
R98	" "	"	84.5 k	±1	0.25 W
R99	Resistor, Code Z	HOLCOH4	68.1 k	±1	0.25 W
R100	" "	"	56.2 k	±1	0.25 W
R101	" "	"	48.7 k	±1	0.25 W
R102	" "	"	42.2 k	±1	0.25 W
R103	" "	"	37.4 k	±1	0.25 W
R104	" "	"	340 k	±1	0.25 W
R105	" "	"	169 k	±1	0.25 W
R106	" "	"	113 k	±1	0.25 W
R107	" "	"	84.5 k	±1	0.25 W
R108	" "	"	68.1 k	±1	0.25 W
R109	" "	"	56.2 k	±1	0.25 W
R110	" "	"	48.7 k	±1	0.25 W
R111	" "	"	42.2 k	±1	0.25 W
R112	" "	"	37.4 k	±1	0.25 W
R113	" "	"	866 k	±1	0.25 W
R114	" "	"	432 k	±1	0.25 W
R115	" "	"	287 k	±1	0.25 W
R116	" "	"	215 k	±1	0.25 W
R117	" "	"	174 k	±1	0.25 W
R118	" "	"	143 k	±1	0.25 W
R119	" "	"	124 k	±1	0.25 W
R120	" "	"	110 k	±1	0.25 W
R121	" "	"	97.6 k	±1	0.25 W
R130	Resistor	BTT	22 M	±10	0.5 W
R131	"	Code Z HOLCOH2	3.4 M	±1	0.5 W
R132	"	Code Z HOLCOH4	1.69M	±1	0.125 W
R133	"	"	1.13 M	±1	0.25 W
R134	"	"	845 k	±1	0.25 W
R135	"	"	681 k	±1	0.25 W
R136	"	"	562 k	±1	0.25 W
R137	"	"	487 k	±1	0.25 W
R138	"	"	422 k	±1	0.25 W
R139	"	"	374 k	±1	0.25 W
R140	"	"	340 k	±1	0.25 W
R141	"	BTT	22 M	±10	0.5 W
R142	"	Code Z HOLCOH2	3.4 M	±1	0.5 W
R143	"	Code Z HOLCOH4	1.69M	±1	0.25 W
R144	"	"	1.13M	±1	0.25 W
R145	"	"	845 k	±1	0.25 W
R146	"	"	681 k	±1	0.25 W
R147	"	"	562 k	±1	0.25 W
R148	"	"	487 k	±1	0.25 W
R149	"	"	422 k	±1	0.25 W
R150	"	"	374 k	±1	0.25 W
R151	"	"	340 k	±1	0.25 W
R152	"	BTT	22 M	±1	0.5 W
R153	"	Code Z HOLCOH2	3.4 M	±1	0.5 W
R154	"	Code Z HOLCOH4	1.69M	±1	0.25 W
R155	"	"	1.13M	±1	0.25 W
R156	"	"	845 k	±1	0.25 W
R157	"	"	681 k	±1	0.25 W
R158	"	"	562 k	±1	0.25 W
R159	"	"	487 k	±1	0.25 W
R160	"	"	422 k	±1	0.25 W
R161	"	"	374 k	±1	0.25 W
R162	"	"	340 k	±1	0.25 W
R163	"	BTT	22 M	±10	0.5 W
R164	"	Code Z HOLCOH4	1.33 M	±1	0.25 W
R165	"	"	665 k	±1	0.25 W
R166	"	"	442 k	±1	0.25 W
R167	"	"	332 k	±1	0.25 W
R168	"	"	267 k	±1	0.25 W
R169	"	"	221 k	±1	0.25 W
R170	"	"	187 k	±1	0.25 W
R171	"	"	165 k	±1	0.25 W
R172	"	"	147 k	±1	0.25 W
R173	"	"	133 k	±1	0.25 W
R174	"	BTT	22 M	±10	0.5 W
R175	"	Code Z HOLCOH2	3.4 M	±1	0.5 W
R176	"	Code Z HOLCOH4	1.69M	±1	0.25 W
R177	"	"	1.13M	±1	0.25 W
R178	"	"	845 k	±1	0.25 W
R179	"	"	681 k	±1	0.25 W
R180	"	"	562 k	±1	0.25 W
R181	"	"	487 k	±1	0.25 W
R182	"	"	422 k	±1	0.25 W
R183	"	"	374 k	±1	0.25 W
R184	"	"	340 k	±1	0.25 W
R185	"	BTT	22M	±10	0.5 W
R186	"	Code Z HOLCOH2	3.4 M	±1	0.5 W
R187	"	Code Z HOLCOH4	1.69M	±1	0.25 W
R188	"	"	1.13M	±1	0.25 W
R189	"	"	845 k	±1	0.25 W
R190	"	"	681 k	±1	0.25 W
R191	"	"	562 k	±1	0.25 W
R192	"	"	487 k	±1	0.25 W
R193	"	"	422 k	±1	0.25 W
R194	"	"	374 k	±1	0.25 W
R195	Resistor	Code Z HOLCOH4	340 k	±1	0.25 W
R196	"	BTT	22 M	±10	0.5 W
R197	"	Code Z HOLCOH2	3.4 M	±1	0.5 W
R198	"	Code Z HOLCOH4	1.69 M	±1	0.25 W
R199	"	"	1.13 M	±1	0.25 W
R200	"	"	845 k	±1	0.25 W
R201	"	"	681 k	±1	0.25 W
R202	"	"	562 k	±1	0.25 W
R203	"	"	487 k	±1	0.25 W
R204	"	"	422 k	±1	0.25 W
R205	"	"	374 k	±1	0.25 W
R206	"	"	340 k	±1	0.25 W
R207	"	BTT	22 M	±1	0.5 W
R208	"	Code Z HOLCOH2	8.66 M	±1	0.5 W
R209	"	"	4.32 M	±1	0.5 W
R210	"	"	2:87 M	±1	0.5 W
R211	"	"	2.15 M	±1	0.5 W
R212	"	Code Z HOLCOH4	1.74 M	±1	0.25 W
R213	"	"	1.43 M	±1	0.25 W
R214	"	"	1.24 M	±1	0.25 W
R215	"	"	1.1 M	±1	0.25 W
R216	"	"	976 k	±1	0.25 W
R217	"	Code Z HOLCOH4	866 k	±1	0.25 W
C1	Capacitor, Electrolytic	C 426 AR/F50	50 µF	+50 −10	25 V
C2	" "	"	"	"	"
C3	" SOLID TANTALUM	TAG 0.1/35	0.1 µF	±20	35 V
C4	" " "	"	0.1 µF	±20	35 V
C5	" POLYSTYRENE	H.S.	*	±10	63 V
C6	" SOLID TANTALUM	TAG 0.1/35	0.1 µF	±20	35 V
C7	" " "	"	0.1 µF	±20	35 V
C8	" POLYSTYRENE	H.S.	*	±10	63 V
C9	" "	H.S.	100 pF	±10	63 V
C10	" CERAMIC	P100/YD	3.6 pF	±0.5	200 V
C11	" METAL. POLYESTER	TROP. 'M'	*	±10	400 V
C21	" "	H.S.	4700pF	±2½	63 V
C22	" POLYCARBONATE	CTR010C	0.047µF	±2	160 V
C23	" "	CMD10C	0.47 µF	±2	63 V
C24	" "	CMD40C	4.7 µF	±2	63 V
C26	" POLYSTYRENE	H.S.	4700pF	±2½	63 V
C27	" POLYCARBONATE	CTR010C	0.047µF	±2	160 V
C28	" "	CMD10C	0.47 µF	±2	63 V
C29	" "	CMD40C	4.7 µF	±2	63 V
C31	" POLYSTYRENE	H.S.	4700pF	±2½	63 V
C32	" POLYCARBONATE	CTR010C	0.047µF	±2	160 V
C33	" "	CMD10C	0.47 µF	±2	63 V
C34	" "	CMD40C	4.7 µF	±2	63 V
C36	" POLYSTYRENE	H.S.	4700pF	±2½	63 V
C37	" POLYCARBONATE	CTR010C	0.047µF	±2	160 V
C38	" "	CMD10C	0.47 µF	±2	63 V
C39	" "	CMD40C	4.7 µF	±2	63 V
C41	" POLYSTYRENE	H.S.	4700pF	±2½	63 V
C42	" POLYCARBONATE	CTR010C	0.047µF	±2	160 V
C43	" "	CMD10C	0.47 µF	±2	63 V
C44	" "	CMD40C	4.7 µF	±2	63 V
C46	" POLYSTYRENE	H.S.	4700pF	±2½	63 V
C47	" POLYCARBONATE	CTR010C	0.047µF	±2	160 V
C48	" "	CMD10C	0.47µF	±2	63 V
C49	" "	CMD40C	4.7 µF	±2	63 V
C51	" POLYSTYRENE	H.S.	4700pF	±2½	63 V
C52	" POLYCARBONATE	CTR010C	0.047µF	±2	160 V
C53	" "	CMD10C	0.47µF	±2	63 V
C54	" "	CMD40C	4.7 µF	±2	63 V
C56	" POLYSTYRENE	H.S.	4700pF	±2½	63 V
C57	" POLYCARBONATE	CTR010C	0.047µF	±2½	160 V
C58	" "	CMD10C	0.47µF	±2	63 V
C59	" "	CMD40C	4.7 µF	±2	63 V
D1	Zener Diode (Mullard)	BYZ88/C5V6		±5	5.6V
D2	" " "	"		"	"
D3	Diode (I.T.T.)	IN4148			
D4	" "	"			
D5	" "	"			
D6	" "	"			
D7	" "	"			
D8	" "	"			
PL1	Plug, 15 Way	DA15P			
SK2	Socket, Edge Connector	6P55670AH 32 7127			
SK3	Coaxial Connector	UG1094A/U			
SK4	" "	"			
SK5	" "	"			
SK6	" "	"			

NOTE: D3 to D7 (EF3-01 high-pass unit) and D3, D4, D5, D7 (EF3-02 low-pass unit) are only fitted if found necessary during test procedure.

Circuit Ref.	Description	Ref. No.	Value Ω	Tol. %	Rating
X1	Operational Amplifier	LM310N			
X2	" "	"			
X3	" "	"			
X4	" "	"			
X5	" "	"			
X6	" "	"			
X7	" "	"			
X8	" "	1321			
X9	" "	LM310N			
X10	" "	"			
S2	Switch	B/EF3020			
S3	"	B/EF3021			
S4	"	"			
S5	"	B/EF3022			

Filter Unit EF3-01 (High-Pass) only

Circuit Ref.	Description	Ref. No.	Value	Tol.%	Rating
R220	Resistor	MR 25	15 kΩ	±2	0.4 W
C15	Capacitor, Polystyrene	H.S.	10 pF	±10	160 V
C20	Capacitor, "	H.S.	470 pF	±2½	63 V
C25	" "	H.S.	470 pF	±2½	63 V
C30	" "	H.S.	470 pF	±2½	63 V
C35	" "	H.S.	470 pF	±2½	63 V
C40	" "	H.S.	470 pF	±2½	63 V
C45	" "	H.S.	470 pF	±2½	63 V
C50	" "	H.S.	470 pF	±2½	63 V
C55	" "	H.S.	470 pF	±2½	63 V
C60	" "	MD 50B	10 µF	±5	63 V

Filter Unit EF3-02 (Low-Pass) only

Circuit Ref.	Description	Ref. No.	Value Ω	Tol. %	Rating
C20	Capacitor, Polystyrene	LCR	420pF	±1	125V
C25	" "	"	"	"	"
C30	" "	"	"	"	"
C35	" "	"	"	"	"
C40	" "	"	390pF	"	"
C45	" "	"	"	"	"
C50	" "	"	"	"	"
C55	" "	"	"	"	"

*C5, C8 and C11 may be fitted if found necessary during test procedure. Values are given on capacitors.

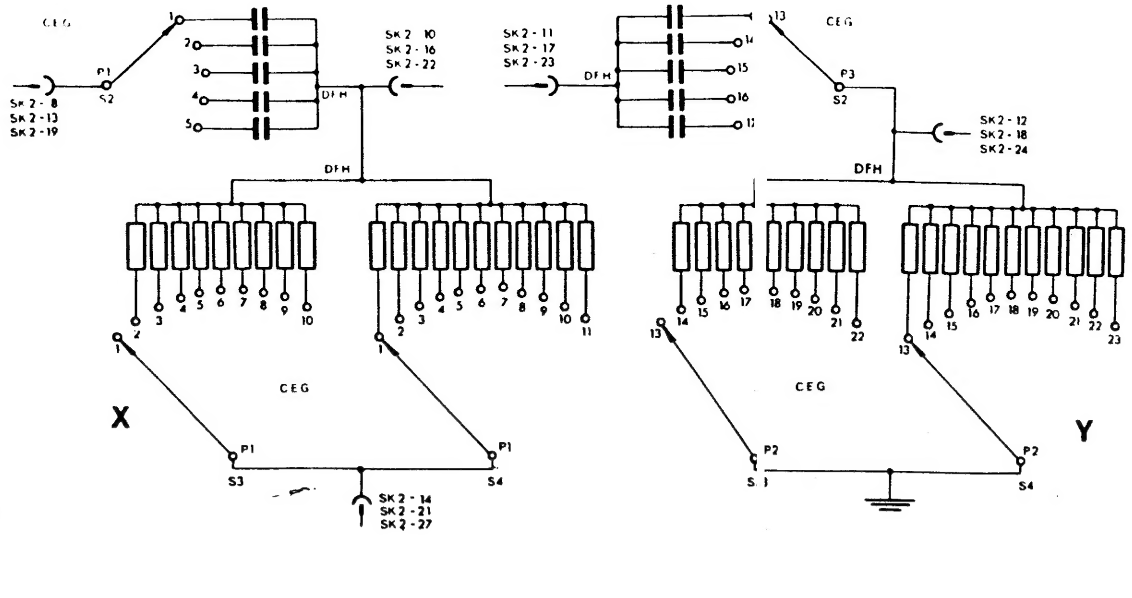
Components List: Filter Units EF3-01 & EF 3-02 **Figure 7**

Components Reference Table

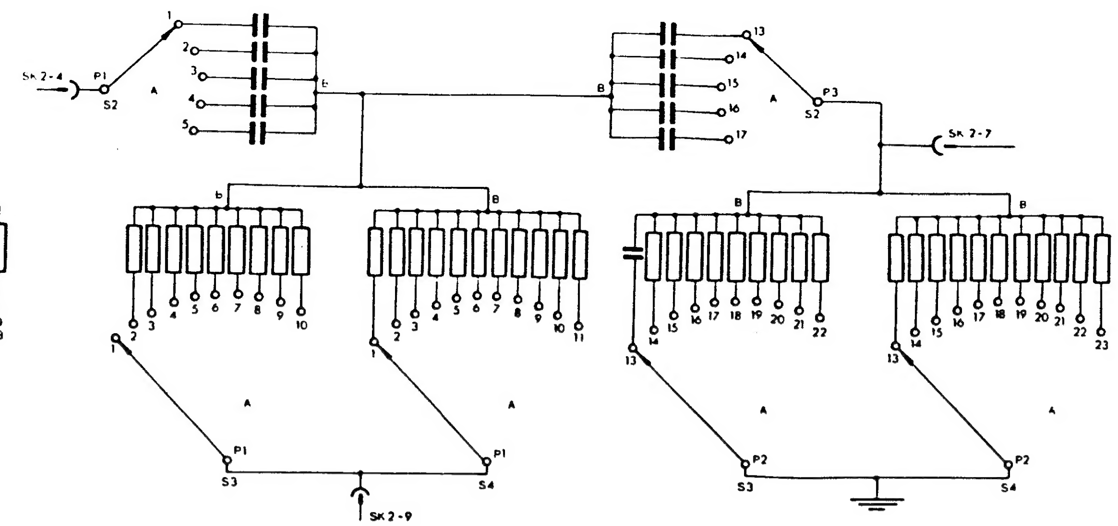
Switch	Switch Positions	Pole Pin	RC 1 From Wafer A to B	RC 2 From Wafer C to D	RC 3 From Wafer E to F	RC 4 From Wafer G to H
S 2	1	P1	C 24	C 34	C 44	C 54
	2		C 23	C 33	C 43	C 53
	3		C 22	C 27	C 32	C 37
	4		C 21	C 26	C 31	C 36
	5		C 20	C 25	C 30	C 35
	7	P2				
	8					
	9					
	10					
	11					
	13	P3	C 29	C 39	C 49	C 59
	14		C 28	C 38	C 48	C 58
	15		C 42	C 47	C 52	C 57
	16		C 41	C 46	C 51	C 56
	17		C 40	C 45	C 50	C 55
	19	P4				
	20					
	21					
	22					
	23					
S 3	1	P1				
	2		R 50	R 59	R 68	R 77
	3		R 51	R 60	R 69	R 78
	4		R 52	R 61	R 70	R 79
	5		R 53	R 62	R 71	R 80
	6		R 54	R 63	R 72	R 81
	7		R 55	R 64	R 73	R 82
	8		R 56	R 65	R 74	R 83
	9		R 57	R 66	R 75	R 84
	10		R 58	R 67	R 76	R 85
	13	P2				
	14		R 86	R 95	R 104	R 113
	15		R 87	R 96	R 105	R 114
	16		R 88	R 97	R 106	R 115
	17		R 89	R 98	R 107	R 116
	18		R 90	R 99	R 108	R 117
	19		R 91	R 100	R 109	R 118
	20		R 92	R 101	R 110	R 119
	21		R 93	R 102	R 111	R 120
	22		R 94	R 103	R 112	R 121
S 4	1	P1	R 130	R 141	R 152	R 163
	2		R 131	R 142	R 153	R 164
	3		R 132	R 143	R 154	R 165
	4		R 133	R 144	R 155	R 166
	5		R 134	R 145	R 156	R 167
	6		R 135	R 146	R 157	R 168
	7		R 136	R 147	R 158	R 169
	8		R 137	R 148	R 159	R 170
	9		R 138	R 149	R 160	R 171
	10		R 139	R 150	R 161	R 172
	11		R 140	R 151	R 162	R 173
	13	P2	R 174	R 185	R 196	R 207
	14		R 175	R 186	R 197	R 208
	15		R 176	R 187	R 198	R 209
	16		R 177	R 188	R 199	R 210
	17		R 178	R 189	R 200	R 211
	18		R 179	R 190	R 201	R 212
	19		R 180	R 191	R 202	R 213
	20		R 181	R 192	R 203	R 214
	21		R 182	R 193	R 204	R 215
	22		R 183	R 194	R 205	R 216
	23		R 184	R 195	R 206	R 217

NOTES: (i) All wafers on common switch reference are mechanically coupled.
(ii) The component values are shown on Figure 7 (EF3-01 & EF3-02) and Figure 10 (EF3-03 & EF3-04).

Filter Unit EF3-01 & EF3-03 (High-Pass)

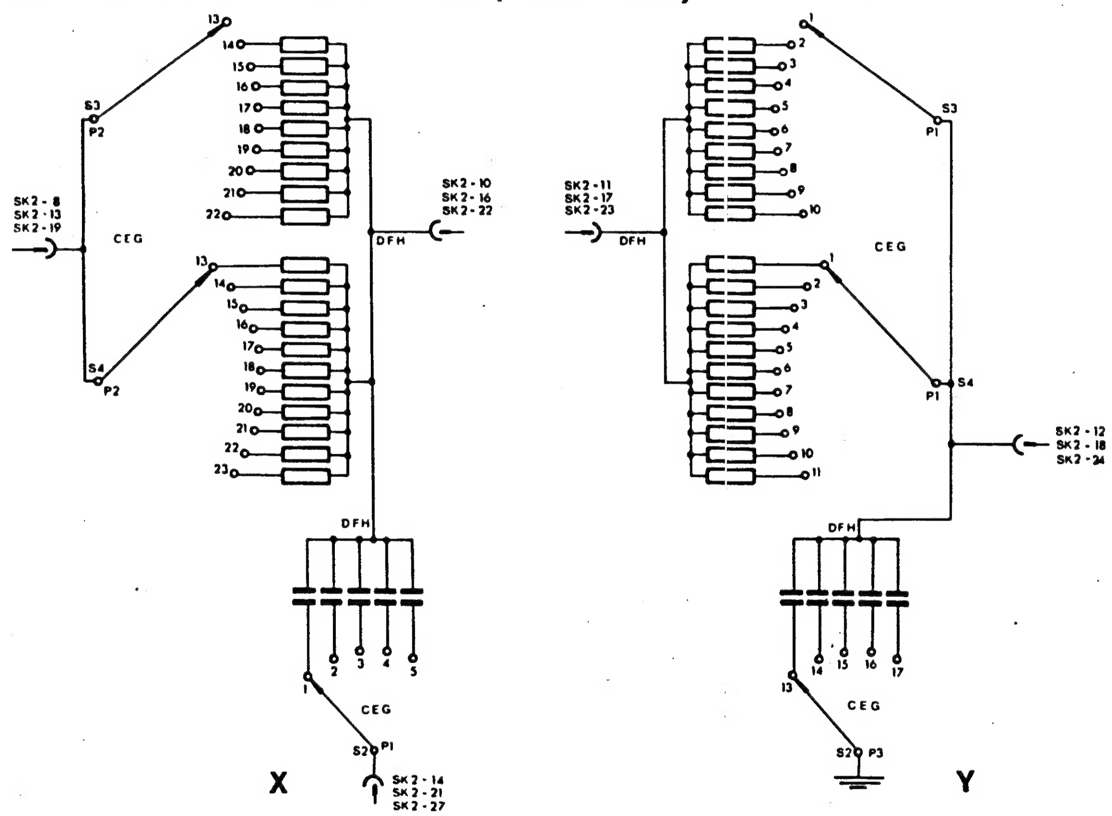


R·C SECTIONS 2 – 4 INC X and Y.

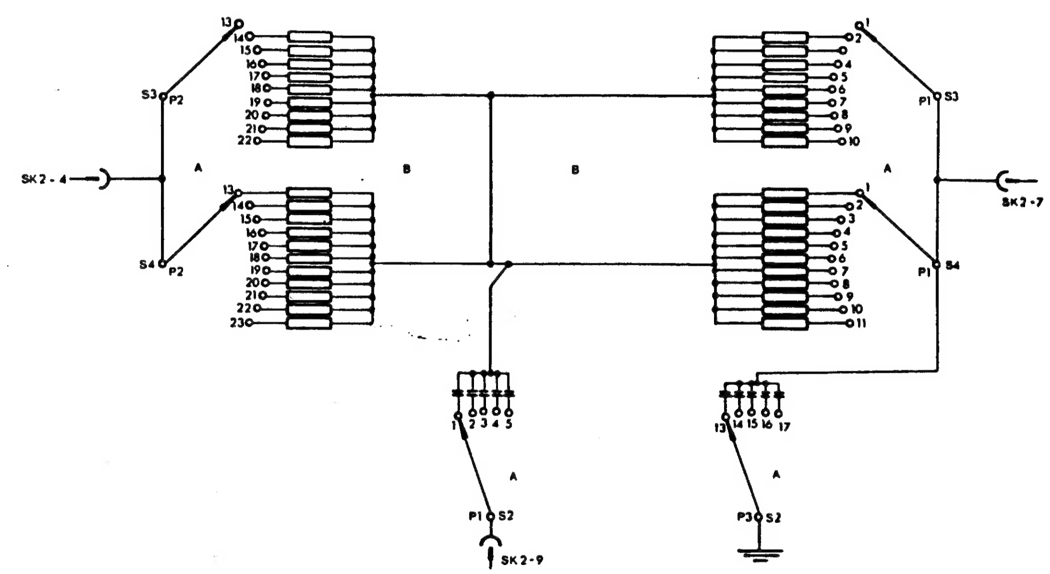


R·C SECTION 1.

Filter Unit EF3-02 & EF3-04 (Low-Pass)



R·C SECTIONS 2 – 4 INC X and Y.

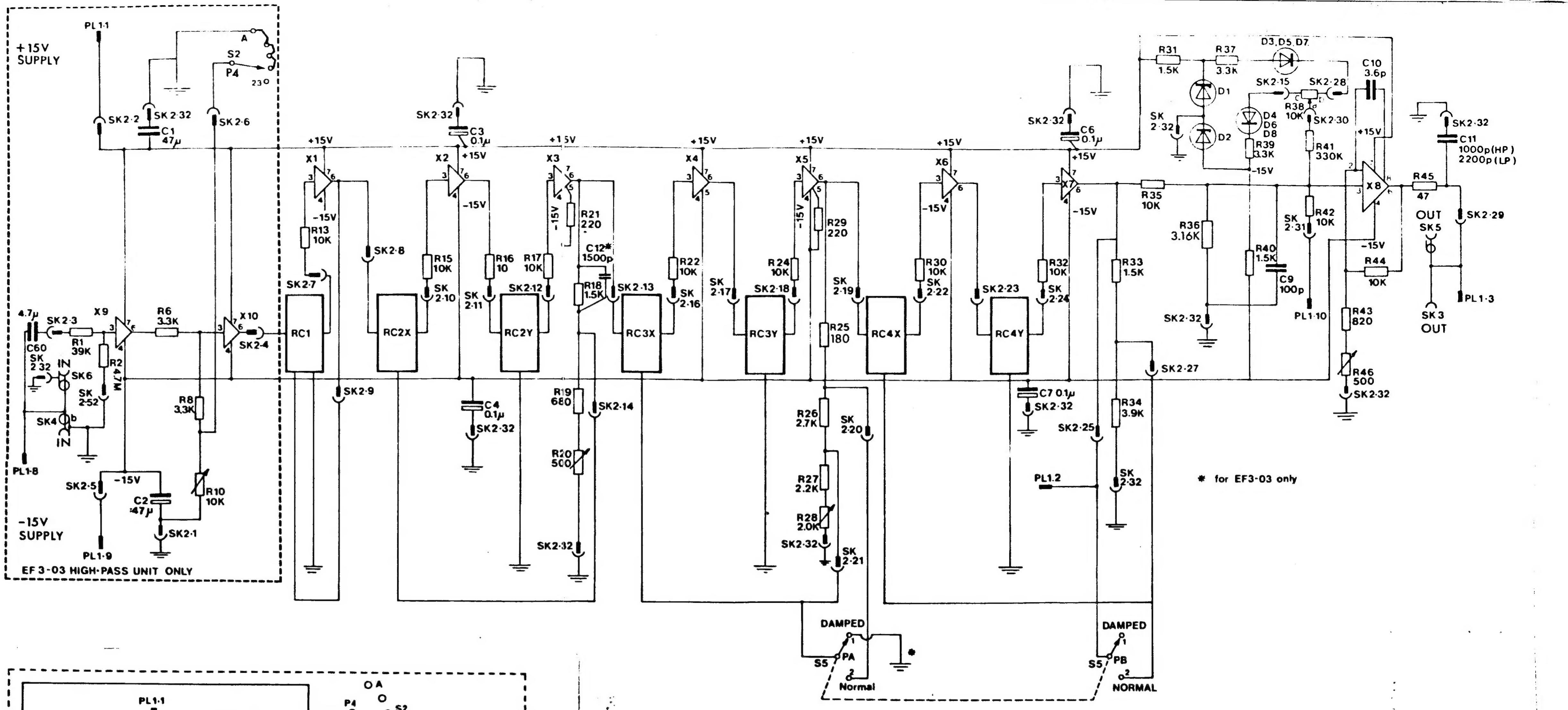


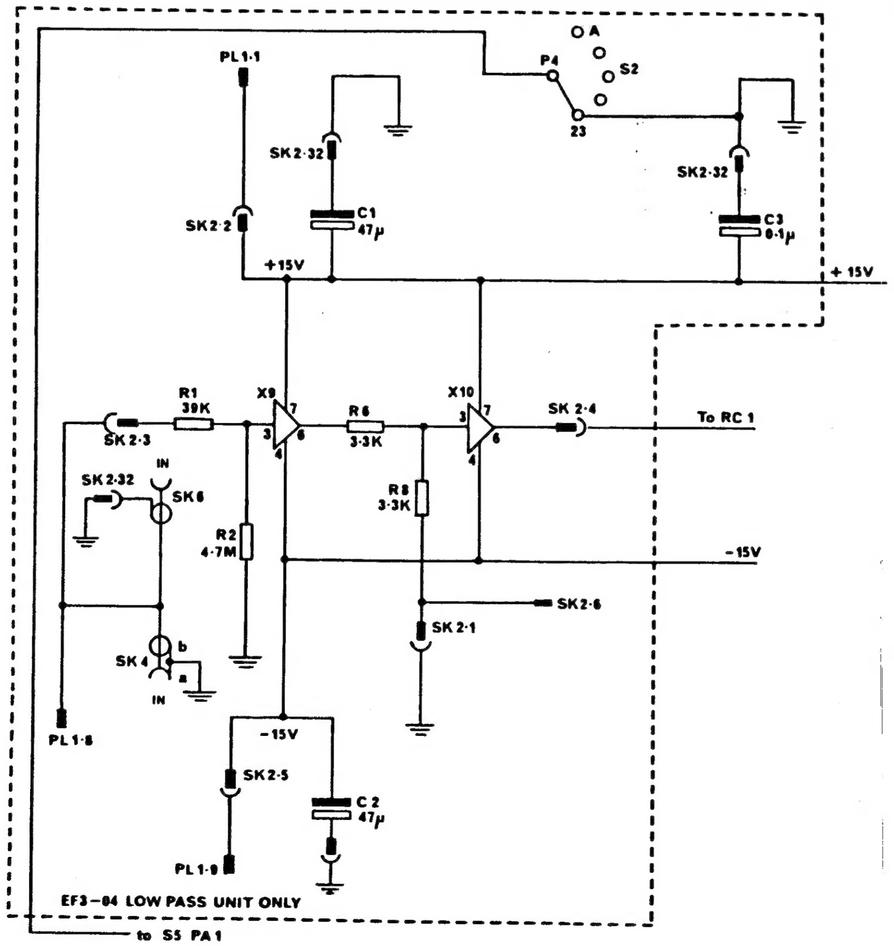
R·C SECTION 1.

C23
C28. 0·47μF

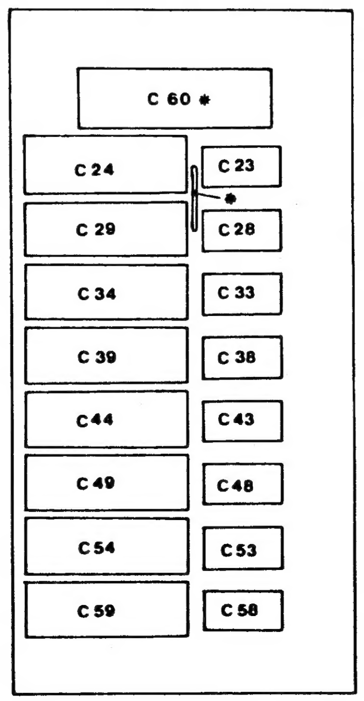
R-C Sections : Filter Units EF3-01, EF3-02, EF3-03 & EF3-04

Figure 8

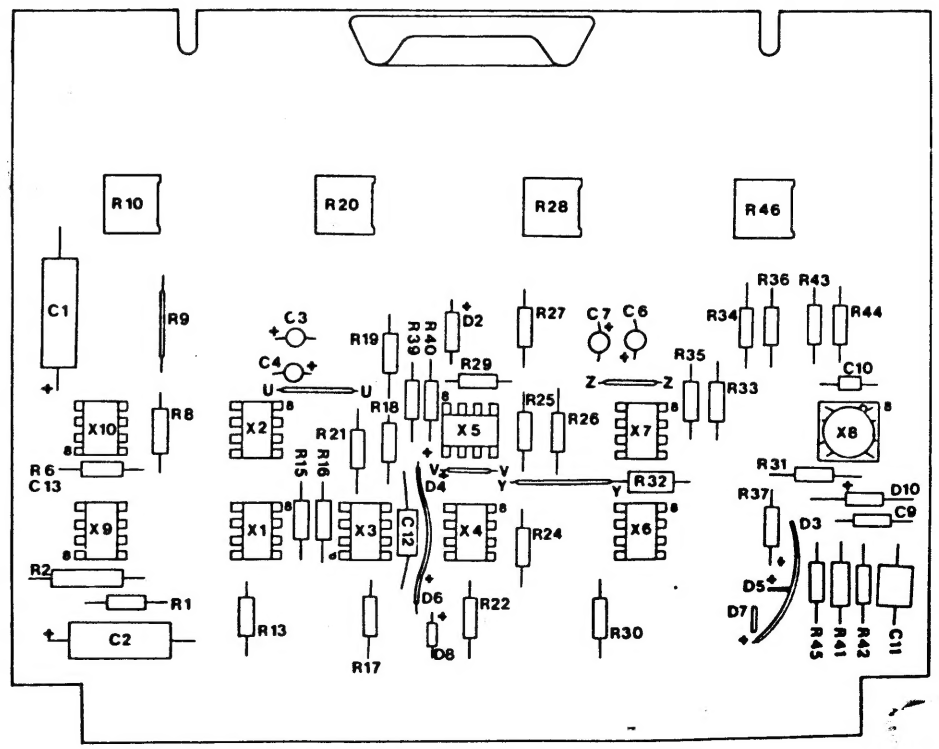




Capacitor Board



Printed Circuit Board



Circuit Diagram: Filter Units EF3-03 & EF3-04 Figure 9

Filter Units EF3-03 (High-Pass) & EF3-04 (Low-Pass)

Circuit Ref.	Description	Ref. No.	Value Ω	Tol. %	Rating
R1	Resistor (Mullard)	CR 25	39K	±5	0.33W
R2	Resistor (Dubilier)	BTT	4.7M	±10	0.25W
R6	Resistor (Mullard)	MR25	3.3K	±2	0.4W
R8	" "	"	"	"	"
R13	" "	CR25	10K	±5	0.33W
R15	" "	"	"	"	"
R16	" "	"	10Ω	"	"
R17	" "	"	10K	"	"
R18	" "	"	1.5K	"	"
R19	" "	"	680	"	"
R20	Resistor, Var. (Beckman)	72P	500	±20	0.5W
R21	Resistor (Mullard)	CR25	220	±5	0.33W
R22	" "	"	10K	"	"
R24	" "	"	"	"	"
R25	" "	"	180	"	"
R26	" "	"	2.7K	"	"
R27	" "	"	2.2K	"	"
R28	Resistor, Var. (Beckman)	72P	2.0K	±20	0.5W
R29	Resistor (Mullard)	CR25	220	±5	0.33W
R30	" "	"	10K	"	"
R31	" "	"	1.5K	"	"
R32	" "	"	10K	"	"
R33	" "	"	1.5K	"	"
R34	" "	"	3.9K	"	"
R35	" "	MR25	10K	±2	0.4W
R36	" "	"	3.16K	"	"
R37	" "	CR25	3.3K	±5	0.33W
R38	Resistor, Variable	A/EF3025	10K	±20	0.75W
R39	Resistor (Mullard)	CR25	3.3K	±5	0.33W
R40	" "	"	1.5K	±5	"
R41	" "	"	330K	"	"
R42	" "	MR25	10K	±2	0.4W
R43	" "	"	820	"	"
R44	" "	"	10K	"	"
R45	" "	CR25	47	±5	0.33W
R46	Resistor, (Var. (Beckman)	72P	500	±20	0.5W
R50	Resistor, Holco	'Z'H8	34K	±1	0.25W
R51	" "	"	16.9K	"	"
R52	" "	"	11.3K	"	"
R53	" "	"	8.45K	"	"
R54	" "	"	6.81K	"	"
R55	" "	"	5.62K	"	"
R56	" "	"	4.87K	"	"
R57	" "	"	4.22K	"	"
R58	" "	"	3.74K	"	"
R59	" "	"	34K	"	"
R60	" "	"	16.9K	"	"
R61	" "	"	11.3K	"	"
R62	" "	"	8.45K	"	"
R63	" "	"	6.81K	"	"
R64	" "	"	5.62K	"	"
R65	" "	"	4.87K	"	"
R66	" "	"	4.22K	"	"
R67	" "	"	3.74K	"	"
R68	" "	"	34K	"	"
R69	" "	"	16.9K	"	"
R70	" "	"	11.3K	"	"
R71	" "	"	8.45K	"	"
R72	" "	"	6.81K	"	"
R73	" "	"	5.62K	"	"
R74	" "	"	4.87K	"	"
R75	" "	"	4.22K	"	"
R76	" "	"	3.74K	"	"
R77	" "	"	13.3K	"	"
R78	" "	"	6.65K	"	"
R79	" "	"	4.42K	"	"
R80	" "	"	3.32K	"	"
R81	" "	"	2.67K	"	"
R82	" "	"	2.21K	"	"
R83	" "	"	1.87K	"	"
R84	" "	"	1.65K	"	"
R85	" "	"	1.47K	"	"
R86	" "	"	34K	"	"
R87	" "	"	16.9K	"	"
R88	" "	"	11.3K	"	"
R89	" "	"	8.45K	"	"
R90	" "	"	6.81K	"	"
R91	" "	"	5.62K	"	"
R92	" "	"	4.87K	"	"
R93	" "	"	4.22K	"	"
R94	" "	"	3.74K	"	"
R95	" "	"	34K	"	"
R96	" "	"	16.9K	"	"
R97	" "	"	11.3K	"	"
R98	" "	"	8.45K	"	"
R99	" "	"	6.81K	"	"
R100	" "	"	5.62K	"	"
R101	Resistor, Holco	'Z'H8	4.87K	±1	0.25W
R102	" "	"	4.22K	"	"
R103	" "	"	3.74K	"	"
R104	" "	"	34K	"	"
R105	" "	"	16.9K	"	"
R106	" "	"	11.3K	"	"
R107	" "	"	8.45K	"	"
R108	" "	"	6.81K	"	"
R109	" "	"	5.62K	"	"
R110	" "	"	4.87K	"	"
R111	" "	"	4.22K	"	"
R112	" "	"	3.74K	"	"
R113	" "	"	86.6K	"	"
R114	" "	"	43.2K	"	"
R115	" "	"	28.7K	"	"
R116	" "	"	21.5K	"	"
R117	" "	"	17.4K	"	"
R118	" "	"	14.3K	"	"
R119	" "	"	12.4K	"	"
R120	" "	"	11K	"	"
R121	" "	"	9.76K	"	"
R130	Resistor, A. Bradley	E.B.	22M	±10	"
R131	Resistor, Holco	'Z'H8	340K	±1	"
R132	" "	"	169K	"	"
R133	" "	"	113K	"	"
R134	" "	"	84.5K	"	"
R135	" "	"	68.1K	"	"
R136	" "	"	56.2K	"	"
R137	" "	"	48.7K	"	"
R138	" "	"	42.2K	"	"
R139	" "	"	37.4K	"	"
R140	" "	"	34K	"	"
R141	Resistor, A. Bradley	E.B.	22M	±10	"
R142	Resistor, Holco	'Z'H8	340K	±1	"
R143	" "	"	169K	"	"
R144	" "	"	113K	"	"
R145	" "	"	84.5K	"	"
R146	" "	"	68.1K	"	"
R147	" "	"	56.2K	"	"
R148	" "	"	48.7K	"	"
R149	" "	"	42.2K	"	"
R150	" "	"	37.4K	"	"
R151	" "	"	34K	"	"
R152	Resistor, A. Bradley	E.B.	22M	±10	"
R153	Resistor, Holco	'Z'H8	340K	±1	"
R154	" "	"	169K	"	"
R155	" "	"	113K	"	"
R156	" "	"	84.5K	"	"
R157	" "	"	68.1K	"	"
R158	" "	"	56.2K	"	"
R159	" "	"	48.7K	"	"
R160	" "	"	42.2K	"	"
R161	" "	"	37.4K	"	"
R162	" "	"	34K	"	"
R163	Resistor, A. Bradley	E.B.	22M	±10	"
R164	Resistor, Holco	'Z'H8	133K	±1	"
R165	" "	"	66.5K	"	"
R166	" "	"	44.2K	"	"
R167	" "	"	33.2K	"	"
R168	" "	"	26.7K	"	"
R169	" "	"	22.1K	"	"
R170	" "	"	18.7K	"	"
R171	" "	"	16.5K	"	"
R172	" "	"	14.7K	"	"
R173	" "	"	13.3K	"	"
R174	Resistor, A. Bradley	E.B.	22M	±10	"
R175	Resistor, Holco	'Z'H8	340K	±1	"
R176	" "	"	169K	"	"
R177	" "	"	113K	"	"
R178	" "	"	84.5K	"	"
R179	" "	"	68.1K	"	"
R180	" "	"	56.2K	"	"
R181	" "	"	48.7K	"	"
R182	" "	"	42.2K	"	"
R183	" "	"	37.4K	"	"
R184	" "	"	34K	"	"
R185	Resistor, A. Bradley	E.B.	22M	±10	"
R186	Resistor, Holco	'Z'H8	340K	±1	"
R187	" "	"	169K	"	"
R188	" "	"	113K	"	"
R189	" "	"	84.5K	"	"
R190	" "	"	68.1K	"	"
R191	" "	"	56.2K	"	"
R192	" "	"	48.7K	"	"
R193	" "	"	42.2K	"	"
R194	" "	"	37.4K	"	"
R195	" "	"	34K	"	"
R196	Resistor, A. Bradley	E.B.	22M	±10	0.25W
R197	Resistor, Holco	'Z'H8	340K	±1	"
R198	" "	"	169K	"	"
R199	" "	"	113K	"	"
R200	" "	"	84.5K	"	"
R201	" "	"	68.1K	"	"
R202	" "	"	56.2K	"	"
R203	" "	"	48.7K	"	"
R204	" "	"	42.2K	"	"
R205	" "	"	37.4K	"	"
R206	" "	"	34K	"	"
R207	Resistor, A. Bradley	E.B.	22M	±10	"
R208	Resistor, Holco	'Z'H4	866K	±1	"
R209	" "	'Z'H8	432K	"	"
R210	" "	"	287K	"	"
R211	" "	"	215K	"	"
R212	" "	"	174K	"	"
R213	" "	"	143K	"	"
R214	" "	"	124K	"	"
R215	" "	"	110K	"	"
R216	" "	"	97.6K	"	"
R217	" "	"	86.6K	"	"
C1	Capacitor, Elect. (Mullard)	016-16479	47μF	+50 −20	25V
C2	" " "	"	"	"	"
C3	Capacitor Tant™ (I.T.T.)	TAGO-1/35	0.1μF	±20	35V
C4	" " "	"	"	"	"
C6	" " "	"	"	"	"
C7	" " "	"	"	"	"
C9	Capacitor P'styr. (I.T.T.)	H.S.	100pF	±10	63V
C10	Capacitor Ceramic (I.T.T.)	P100/YD	3.6pF	±½	200V
C21	Capacitor P'styr. (Suflex)	H.S.	4700pF	±2½	30V
C22	Capacitor P'carb. (Adv. F'cap)	CTR010C	.047μF	±2	160V
C23	" " "	CMD10C	.47μF	±2	63V
C24	" " "	CMD40C	4.7μF	±2	"
C26	" P'styr. (Suflex)	H.S.	4700pF	±2½	30V
C27	" P'carb. (Adv. F'cap)	CTR010C	.047μF	±2	160V
C28	" " "	CMD10C	.47μF	"	63V
C29	" " "	CMD40C	4.7μF	"	"
C31	" P'styr. (Suflex)	H.S.	4700pF	±2½	30V
C32	" P'carb. (Adv. F'cap)	CTR010C	.047μF	±2	160V
C33	" " "	CMD10C	.47μF	"	63V
C34	" " "	CMD40C	4.7μF	"	"
C36	" P'styr. (Suflex)	H.S.	4700pF	±2½	30V
C37	" P'carb. (Adv. F'cap)	CTR010C	.047μF	±2	160V
C38	" " "	CMD10C	.47μF	"	63V
C39	" " "	CMD40C	4.7μF	"	"
C42	" P'carb. (Adv. F'cap)	CTR010C	.047μF	"	160V
C43	" " "	CMD10C	.47μF	"	63V
C44	" " "	CMD40C	4.7μF	"	"
C47	" " "	CTR010C	.047μF	"	160V
C48	" " "	CMD10C	.47μF	"	63V
C49	" " "	CMD40C	4.7μF	"	"
C52	" P'carb. (Adv. F'cap)	CTR010C	.047μF	"	160V
C53	" " "	CMD10C	.47μF	"	63V
C54	" " "	CMD40C	4.7μF	"	"
C57	" " "	CTR010C	.047μF	"	160V
C58	" " "	CMD10C	.47μF	"	63V
C59	" " "	CMD40C	4.7μF	"	"
D1	Zener Diode (Mullard)	BYZ88/C5V6		±5	5.6V
D2	" " "	"		"	"
D3	Diode (I.T.T.)	IN4148			
D4	" "	"			
D5	" "	"			
D6	" "	"			
D7	" "	"			
D8	" "	"			
PL1	Plug, 15 Way	DA15P			
SK2	Socket, Edge Connector	6P55670AH 32 7127			
SK3	Coaxial Connector	UG1094A/U			
SK4	" "	"			
SK5	" "	"			
SK6	" "	"			
X1	Operational Amplifier	LM310N			
X2	" "	"			
X3	" "	"			
X4	" "	"			
X5	" "	"			
X6	" "	"			
X7	" "	"			
X8	" "	1321			
X9	" "	LM310N			
X10	" "	"			
S2	Switch	B/EF3020			
S3	"	B/EF3021			
S4	"	"			
S5	"	B/EF3022			

NOTE: D3 to D7 (EF3-03 high-pass unit) and D3, D4, D5, D7 (EF3-04 low-pass unit) are only fitted if found necessary during test procedure.

Filter Unit EF3-03 (High-Pass) only

Circuit Ref.	Description	Ref. No.	Value Ω	Tol. %	Rating
R10	Resistor, Var. (Beckman)	72P	10K	±20	0.5W
R220	Resistor, (Mullard)	CR25	330	±5	0.25W
C11	Capacitor, P'styr. (I.T.T.)	H.S.	1000pF	±10	63V
C12	Capacitor, P'styr. (Suflex)	H.S.	1500pF	±2½	160V
C20	Capacitor, P'styr. (L.C.R.)		470pF	±2	30V
C25	" " "		"	"	"
C30	" " "		"	"	"
C35	" " "		"	"	"
C40	" " "		"	"	"
C41	" " "		4700pF	"	"
C45	" " "		470pF	"	"
C46	" " "		4700pF	"	"
C50	" " "		470pF	"	"
C51	" " "		4700pF	"	"
C55	" " "		470pF	"	"
C56	" " "		4700pF	"	"
C60	" P'carb. (Adv. F'cap)	CMR40A	4.7μF	±10	160V

Filter Unit EF3-04 (Low-Pass) only

Circuit Ref.	Description	Ref. No.	Value Ω	Tol. %	Rating
C11	Capacitor, P'styr. (I.T.T.)	H.S.	2200pF	±10	63V
C20	Capacitor, P'styr. (L.C.R.)		420pF	±2	30V
C25	" " "		"	"	"
C30	" " "		"	"	"
C35	" " "		"	"	"
C40	" " "		390pF	"	"
C41	" " "		4500pF	"	"
C45	" " "		390pF	"	"
C46	" " "		4500pF	"	"
C50	" " "		390pF	"	"
C51	" " "		4500pF	"	"
C55	" " "		390pF	"	"
C56	" " "		4500pF	"	"

Components List: Filter Units EF3-03 & EF3-04

Figure 10